POWER

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What do you know?

A MAN'S worth to the world depends largely upon what he knows.

The thing that makes you who read this valuable to your employer, that enables you to earn a living — and I hope something more — is that you know how to do something for which he is willing to pay.

It may be making steam out of coal and water; it may be running an engine; it may be managing a power plant; it may be designing central stations.

It took you some time to learn how to do this, maybe; but as you look back over it, it appears very simple. If you had to learn it over again you could do it with much less effort and in much less time than you thought it was going to take.

Think over a few of the fundamental things that you know which are of the most use to you, the knowledge of which has brought you the most profit and satisfaction. The time and effort spent in their acquisition was small, was it not, compared with the satisfaction and benefit that you have derived from them?

It may be that there are others in your line who hold better positions than you do. Is it because they have more of these acquirements? Is it because they have been learning more of these things and have the qualification and the confidence, that comes with knowledge, to take on greater responsibilities?

I have in mind a poor fellow who thinks he has reached his limit and is condemned to a life of manual labor and mediocrity because he can "just do decimals slow." A few weeks of evenings spent at home, or of odd moments during the day, with a common school arithmetic would remove the deficiency that holds him down, and a few months more of self study with a few elementary textbooks would open up to him the whole range of ordinary engineering literature.

An engineer in a small way — one of the kind that they want to call "engineman" — gets interested in what is going on under his boilers. Perhaps his interest is caught by an article or a lecture on combustion or inspired by the visit of some salesman or by the talk or achievements of another engineer. He begins to read and think and study. There are no end of simple, understandable, interesting things to be had upon the subject. He tries things out, he makes experiments. Talk about lack of opportunity—the man with a steam plant to jockey with has all kinds of advantage over a white-collar student with no chance to try out his ideas or apply his learning. He makes improvements, learns to keep and interpret records to better his results, and before he knows it he is saving several times his salary and getting a reputation as a combustion engineer.

Another who has performed mechanically the operations necessary to manipulate and maintain the electrical machinery under his charge, picks up a handbook upon the subject and finds that the mystery in which he had supposed it to be shrouded is easily penetrable by a man of the most ordinary acquirements, and that a moderate amount of reading and study gives him a new insight into and interest in this phase of his work and qualifies him to understand and undertake jobs which he had thought were entirely beyond him.

Many a man has passed his life in a humble sphere, hedged in by limitations which he could have broken through by an effort which, looked back upon after it had been made, would have appeared to him extremely trivial.

F. R. Low

Low-Ash Coal Not Always Desirable

A Discussion of Conditions Under Which It Was Found That Coal with a High Ash Content Reduced Stoker Trouble

BY S. W. FLAGG*

DURING the last few years much has been said in condemnation of coal operators because of the poor quality of coal for which heretofore unheard-of prices were paid, and in defense the operators have argued that under the labor conditions existing it was impossible to secure proper preparation. Even in normal times, however, complaints about excessive ash content or low B.t.u. values are not uncommon, but rarely do we ever hear of a coal being too good or not having enough ash. For this reason a case of stoker trouble that the author had occasion to investigate some years ago will be of interest.

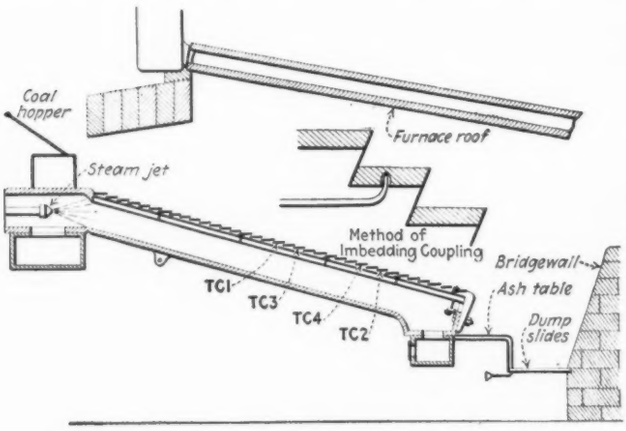


FIG. 1. CROSS-SECTION OF FURNACE, SHOWING LOCATION OF COUPLES

The plant contained six boilers of a horizontally baffled water-tube type, each of approximately 2,500 sq.ft. heating surface, equipped with Wilkinson stokers. The stokers were originally installed for burning anthracite, but had been modified and had been used for several years with bituminous coals produced in Pennsylvania, Maryland or West Virginia. The plant furnished steam for heating, lighting and elevator service—a typical office-building load. Fig. 1 shows a longitudinal cross-section of the furnace with its C-tile roof. The grate surface was made up of a number of hollow bars of approximately 4 in. width, the removable tops of which formed a stepped surface with the air openings in the vertical faces. Every alternate bar was fixed and the adjacent bars were given a horizontal reciprocating motion which was susceptible of adjustment. The upper and outer ends of the bars were open, and into them were directed a row of steam jets which forced in the air for combustion. The supply of steam for the jets was in turn controlled by a diaphragm regulator so as to hold the steam pressure within certain limits.

After a short preliminary trial in the plant, a contract was made for the supply of a high-grade West Virginia coal of which the following analysis is representative: *Proximate Analysis of Coal (as received)*—Moisture, 2.98 per cent; Volatile Matter, 21.32 per cent; Fixed Carbon, 74.38 per cent; Ash, 4.30 per cent; Sulphur, 0.73 per cent; B.t.u. per lb., 14,585; Range of ash softening temperatures 2,224-2,448 deg. F.

Soon after the use of this fuel was begun, trouble arose due to the burning of the tops of the grate bars and in some instances the burning of the bars themselves. The cases of burning were so frequent that the expense of stoker maintenance became prohibitive and, what was more serious, it was a question whether a sufficient number of boilers could be kept in service.

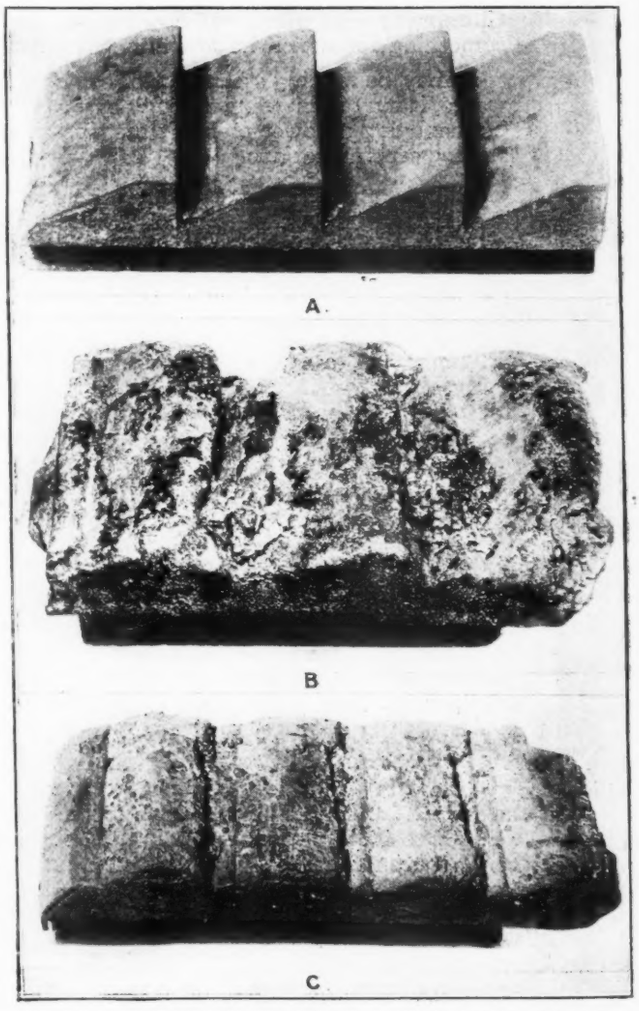
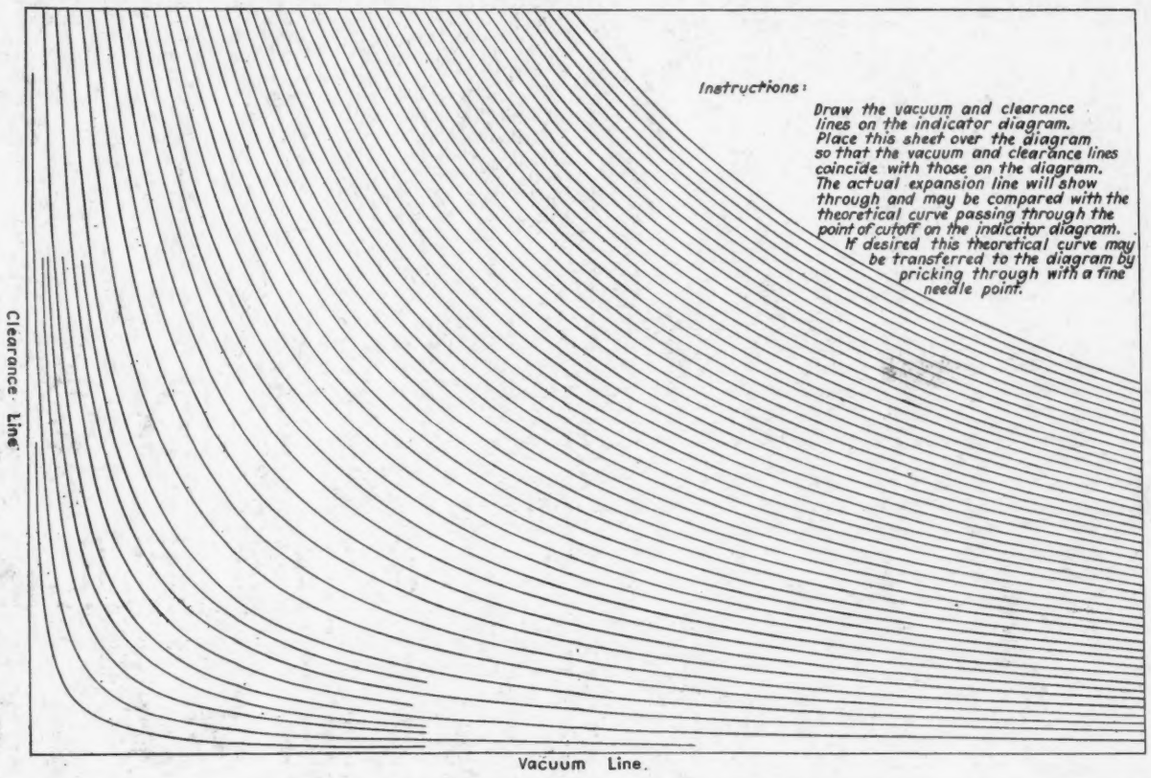


FIG. 2. SECTION OF GRATE BEFORE AND AFTER BURNING

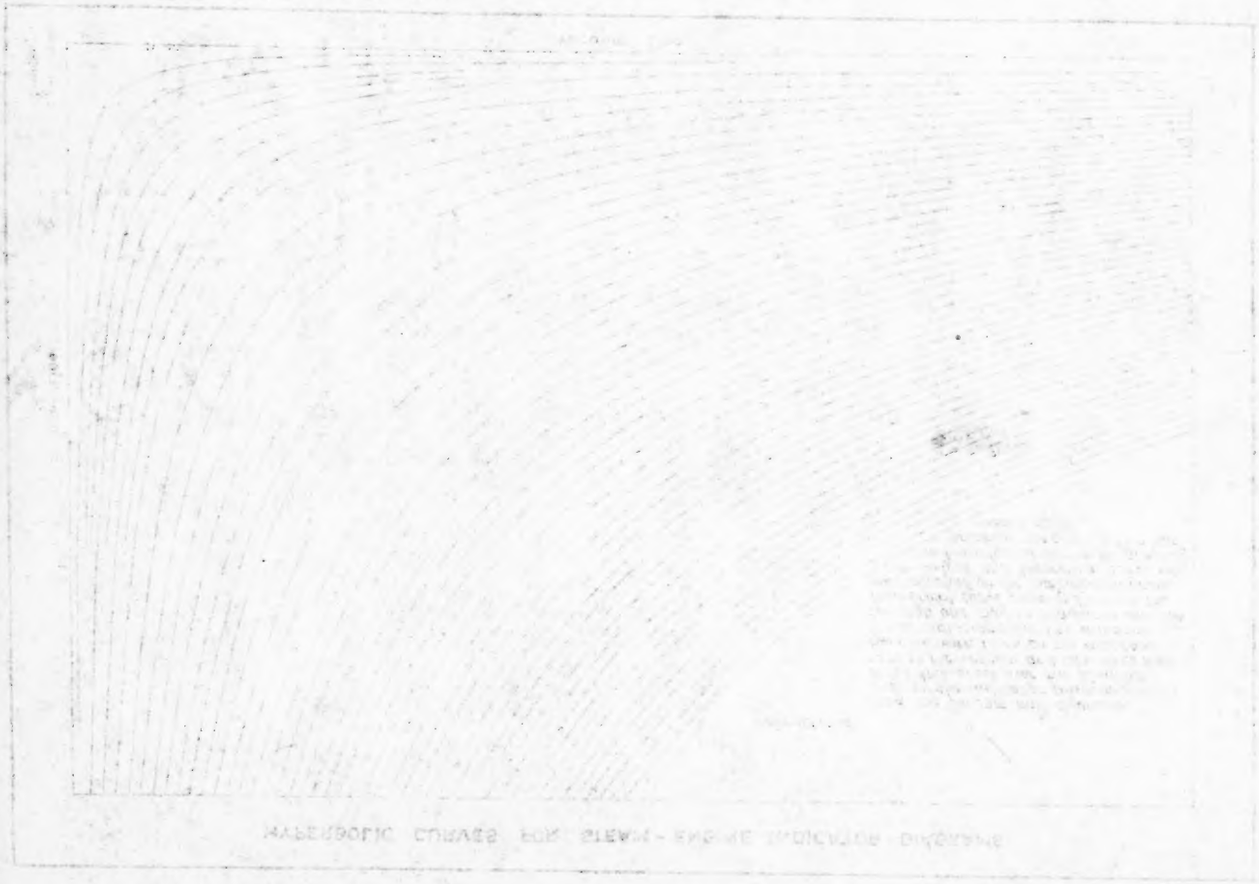
When the first reports of trouble were received, a preliminary investigation was made, as a result of which it was decided to arrange a bypass around the diaphragm regulator valve so as to prevent the supply of steam being entirely cut off from the jets at the ends of the grate bars. The men were cautioned against

*Electric Bond and Share Co., New York City.

HYPERBOLIC CURVES FOR STEAM-ENGINE INDICATOR DIAGRAMS


Instructions:
Draw the vacuum and clearance lines on the indicator diagram. Place this sheet over the diagram so that the vacuum and clearance lines coincide with those on the diagram. The actual expansion line will show through and may be compared with the theoretical curve passing through the point of cutoff on the indicator diagram. If desired this theoretical curve may be transferred to the diagram by pricking through with a fine needle point.
Clearance Line
Vacuum Line.

Supplement to POWER, February 28, 1922



shutting off these jets by hand as had been the practice every few hours while the firemen removed the accumulated siftings from the windbox, on which the lower ends of the grate bars rested. At the same time it was decided to try out grate-bar tops with larger air openings.

Some idea of the damage to the bars may be gained by an examination of Fig. 2. Fig. 2 A shows a new section of the top and B and C are portions of burned tops. In Fig. 3 the middle casting *B* is a burned section of a top having the size of air space originally used, and *A* and *C* are new and damaged sections, respectively, of the tops with the larger air spaces. The seriousness of the problem will be evident when it is explained that conditions such as these and worse were developed frequently after only a few days and sometimes but a few hours of operation.

As the failure kept recurring, plans were made for a thorough investigation to determine the cause of the trouble. One of the stokers was overhauled to insure that all the grate bars were in good condition when the fire was started up. Provision was made to measure temperatures of two of the tops on each of two bars, by embedding in the cast iron the hot junctions of four thermocouples. This was done by drilling the top from the under side so that the couple junction could be held in place within ¼ in. of the fuel-bearing face of the top. The thermocouple wires were led out to the outer end of the bars so that they could be connected to a millivoltmeter.

The purpose of taking these temperature measurements was twofold—to determine whether the cutting off of the steam jets resulted in rapid increase in temperature of the bar, and to demonstrate the effect of the ash content of the coal on the heating of the bars. Incidentally, it was the intention to see what effect on the bar temperatures the increase of air space in the bar had. The furnace was therefore started up with the coal of low ash content as received, and as soon as there was a full fire on the grates the observations were

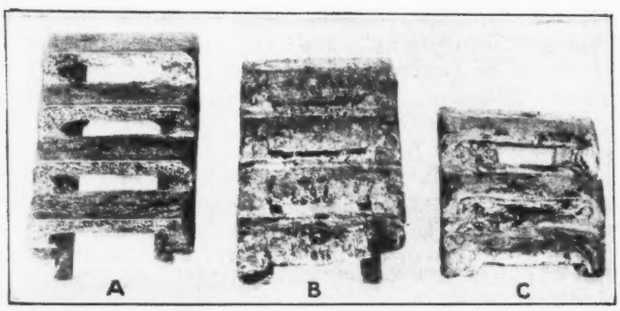


FIG. 3. GRATE BAR, SHOWING EFFECT OF CUTTING OFF STEAM JET

begun. Referring to Fig. 1, the general location of the thermocouples on the grate surface is indicated by the designations *TC*1, *TC*2, etc. In Fig. 4 the four curves show the plotted temperatures as measured. *TC*3 was embedded in a top having the larger air spaces, and the other couples were in tops having the smaller openings. Couples 1 and 2 measured the temperatures on one bar, while the other couples were on another bar. In Fig. 4 it will be noted that the abscissas represent time, but that the preliminary hour is plotted to a different scale from the subsequent period when more frequent readings were being taken.

Referring to the curves in Fig. 4, which represent the readings of couples 1, 2 and 3, respectively, a jump of about 100 deg. will be noted at about one o'clock. This was the result of cutting off the steam jets and consequently the supply of air to the fire (except the very small amount forced through the bed by natural draft). This rise in temperature is not plotted exactly according to scale as regards the time of the observations. Actually, the rise took place in about thirty

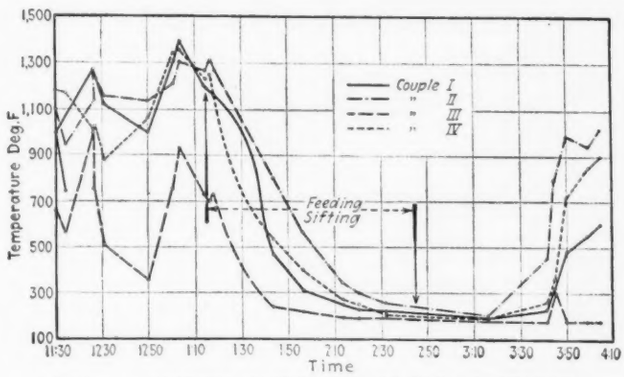


FIG. 4. TEMPERATURES OF GRATES WITHOUT STEAM JETS

seconds and began almost the instant the jets were cut off. On account of the dangerously high temperature and the observed rapidity of rise, it was decided to turn the jets on again as soon as the result of stopping them was demonstrated. The cooling action on the grate bars when the jets were turned on is indicated by the drop in the curve.

During the hour or two that the stoker had been in operation, a considerable amount of fine coal and fine ash had sifted down between the grate bars and accumulated on the floor of the stoker pit. This was now got together and, beginning shortly after one o'clock, it was mixed in with the fresh coal being fed to the furnace so as to increase the ash content of the coal and yet not change the character of the inert matter. The very marked insulating effect of this ash is clearly shown by the rapid drop in the grate-bar temperatures, which during the next hour of operation declined to approximately 200 deg. F. At about 2:45, as indicated on the temperature curves, the feeding of siftings was discontinued, but on account of the thermocouples being located on the lower part of the grate surface, it was some time before the results of resuming the feed of low-ash coal became apparent. Another reason for the lag in temperature curves is that the bars undoubtedly had a protecting coating of ash particles deposited during the period of feeding siftings, and not until the moving fuel bed of low-ash coal had swept this off did the temperatures begin to rise. This may also account for the fact that even after the bars began to heat again, they did not, during the period of observations, reach the high temperatures that had been shown at the start of the test.

When the test was concluded, there was no longer any room for doubt as to the primary cause of the troubles experienced. It was evident that because of the lack of protection for the grate bars afforded by the coals of higher ash content that had formerly been used, the tops of the bars, even while cooled by the flow of air and steam when the jets were on, were heated to temperatures ranging from a dark red to a cherry

color. A sudden decrease of load on the boiler plant, producing movement of the diaphragm regulator and shutting off the jets, soon ran up the temperature of the bar tops and failure resulted. A similar effect was produced, of course, when a fireman shut off the jets on a stoker to clean fires or remove siftings from the windbox, on which the lower ends of the bars rested. Once a hole was burned in the top of the grate, and live fuel dropped into the hollow bar, and if the jets were again started up, an intense heat was produced above and beneath the top of the bar, the result of which can be easily imagined. Such an incident occurred just after the conclusion of the test previously described and furnished striking proof of the correctness of the analysis of the trouble.

It is possible that after further study ways and means of successfully burning this fuel might have been worked out but, obviously, the simplest and cheapest solution of the difficulty was to substitute another coal of higher ash content. This was done and no further reports of trouble were received.

This experience recalled to mind another case of stoker trouble on the study of which the writer had co-operated some time before. A natural-draft chain grate had been installed to burn a low-ash and low-volatile Eastern coal, but the chain heated excessively from the time it was first put in operation. Much of the time the heating was so serious that the chain was of a dark-red color as it passed over the rear sprockets. With the chain at a high temperature the surface of the links became oxidized, a part of the ash was fused into small globules or small flat clinkers possibly $\frac{1}{4}$ in. thick, and this fused ash fastened itself to the oxidized surface of the link. When the clinkers came off some of the link came with them, resulting in such a rapid wasting of the links that it became necessary to rechain the stoker after only a few months' service.

After some study of the effect of different operating conditions, including thickness of fire, average rate of combustion, condition of the fuel, etc., it was found that the worst heating resulted when the boiler operated under fluctuating loads. Up to the time of this discovery all boilers in the plant were connected to a common damper control and sudden rises in steam pressure produced almost complete closing of the damper. Under these conditions it appeared that the decrease in the amount of air passing up through the chain, when combined with the insufficient protection to the grate afforded by the refuse from the low-ash coal, accounted for the rapid increase in temperature of the chain. Subsequently, the automatic damper control was disconnected from the boilers equipped with these stokers, and they were operated under uniform load conditions, the fluctuations being carried by the hand-fired boilers. This resulted in some decrease in the chain temperatures, but the final solution was a change to a coal of higher ash content.

It seems evident also that the composition of the ash in a coal has a marked influence on its heat conductivity, and consequently on its protection to the grates. As an example of this the coals of southeastern Kansas, the ash from which is usually high in iron content, although analyzing from 14 to 20 per cent inert matter, are shown in many cases to produce serious heating when burned on chain grates. All these fuel characteristics are important factors in boiler-plant operation and should be taken into account in selecting fuels for use on present equipment or in choosing stokers.

Where the Energy Goes*

It is of interest to know what becomes of the energy in the steam supplied to a turbine. The accompanying diagram shows this for several classes of turbines. Although exact figures can be given only in the case of a definite installation, this diagram gives a fair idea of the relative division of energy for three classes of turbines.

The length of the upper strip represents all the energy in a given weight of steam. The next strip shows that, while non-condensing operation produces the smallest amount of power from a given weight of steam, it leaves all the rest of the energy in the steam available for heating except for the small amount wasted in bearing friction and radiation. The third strip shows that a bleeder turbine turns a larger percentage of the energy into power, but leaves less for heating. The increased power is accompanied by a large loss of energy to the condenser.

By increasing the amount of steam bled, the distribution of the energy supplied to a bleeder turbine will

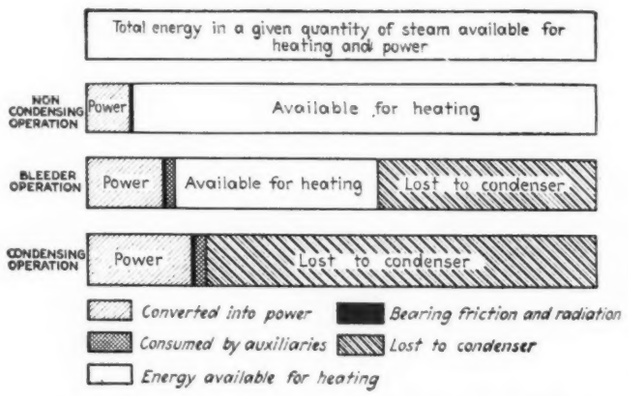


CHART SHOWING WHAT BECOMES OF THE ENERGY SUPPLIED TO A STEAM TURBINE

approach that for non-condensing operation. On the other hand, if no steam is bled, the turbine operates "straight condensing" and we get the distribution shown in the bottom strip for an ordinary turbine operating condensing. This last method of operating gives the maximum power for a given weight of steam, but leaves no steam for heating. The condenser loss is a maximum in this case. In both bleeding and straight-condensing operation there is a small but appreciable consumption of energy by the condenser auxiliaries.

The advantage of the bleeder turbine evidently lies in the fact that any intermediate condition between those shown in the second and fourth strips can be obtained at will and on a moment's notice.

The details of the design of the 200,000-kw. station recently erected at Gennevilliers, near Paris, are awaited with interest. It is reported that the essential features are large boilers, 22,000 sq.ft.; straight-flow turbo-generators of 40,000 normal, 45,000 maximum kw. capacity, at 1,500 r.p.m. in one cylinder; feed-water heating by steam bled from two stages of the main turbine; induced draft with the venturi stack peculiar to the Prat system; duplex drive for some of the auxiliaries, house turbines for reserve; total actual capacity of the plant, 200,000 kw.; ultimate capacity, 320,000 kw.

*Diagram reproduced by permission of Terry Turbine Company.

Expansion Line on the Indicator Diagram

Reasons for Shape of Expansion Line—Laws Governing the Expansion of Steam—Graphical Methods of Constructing Curve

WHEN the admission valve is closed, the steam expands behind the moving piston, and as its volume increases its pressure goes down. If it were a perfect gas and if its temperature stayed constant, the pressure would decrease in the same ratio that the volume increased; that is, if the volume were doubled the pressure would be halved, etc. In Fig. 1, for example, for an initial volume of 1 the pressure is 120 lb., when the volume becomes 2 the pressure is 60, when the volume becomes 3 the pressure is one-third of 120,

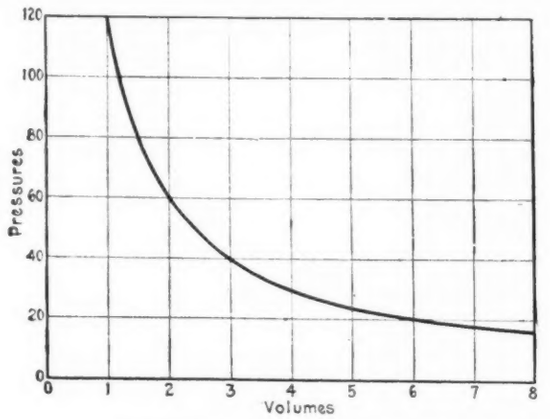


FIG. 1. RELATION OF PRESSURE AND VOLUME

or 40, etc., and at every point in the expansion the product of the pressure and volume is the same.

Vol.	×	Pres.	=	Constant	Vol.	×	Pres.	=	Constant
1	×	120	=	120	5	×	24	=	120
2	×	60	=	120	6	×	20	=	120
3	×	40	=	120	8	×	15	=	120
4	×	30	=	120	10	×	12	=	120

The Ratio of Expansion

The ratio of expansion is the ratio that the final volume of the steam bears to the initial volume. If a cubic foot of steam, Fig. 1, were expanded into 6 cu.ft. the ratio of expansion would be 6. It is the quotient obtained by dividing the volume after expansion by the volume before expansion.

In an engine cylinder the final volume is the piston displacement plus the clearance volume, and the initial volume is the displacement up to cutoff plus the clearance volume. Calling the clearance as a fraction of the piston displacement c and the fraction of the stroke completed at cut off f,

$$\frac{\textit{Final volume} = \textit{displacement} \times (1 + c)}{\textit{Initial volume} = \textit{displacement} \times (f + c)}$$

The displacement cancels out and

$$\text{Ratio of expansion} = \frac{1 + c}{f + c}$$

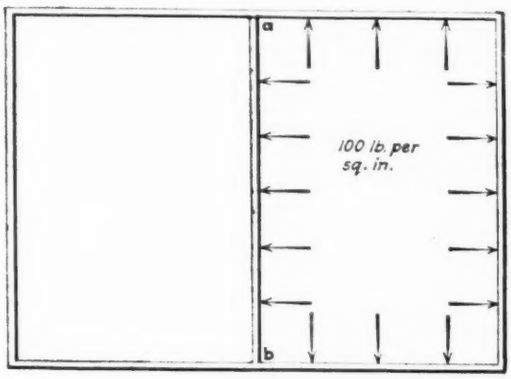


FIG. 2. EFFECT OF INCREASING VOLUME

Example: What is the ratio of expansion in an engine having 5 per cent clearance cutting off at ¼ stroke?

$c = 5$ *per cent, or* 0.5: $f = \frac{1}{4}$ *or* 0.25

$$\text{Ratio of expansion} = \frac{1 + c}{f + c} = \frac{1 + 0.05}{0.25 + .05} = \frac{1.05}{0.30} = 3.5$$

Isothermal Expansion

The mode of expansion in which pv = constant is called isothermal from the Greek prefix *iso* signifying equality or sameness, and the Greek *thermo*, heat, the combination signifying the *constant temperature*, which is its basic characteristic.

What we recognize as the temperature of a body, that which makes it feel warm or cold to the hand or sends

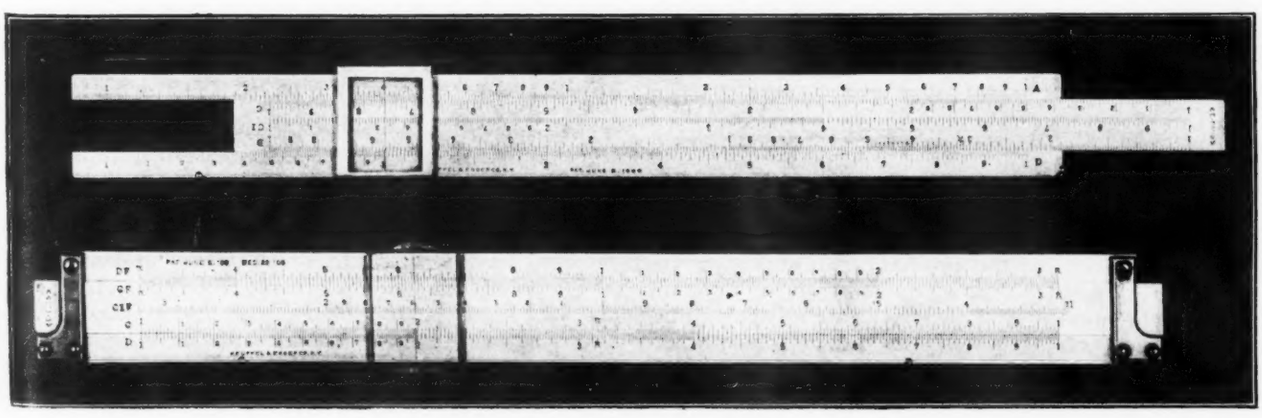


FIG. 3. SLIDE RULES USED TO COMPUTE VALUES

the thermometer up or down, is the velocity, or the momentum of its molecules. Imagine the space at the right of the division *ab* in Fig. 2 to be filled with steam of 100 lb. pressure, absolute. It produces the effect of 100 lb. pressure per sq.in. of surface because there are just enough molecules of steam present, moving with just enough velocity so that each square inch of the containing surface gets hit times enough and hard enough

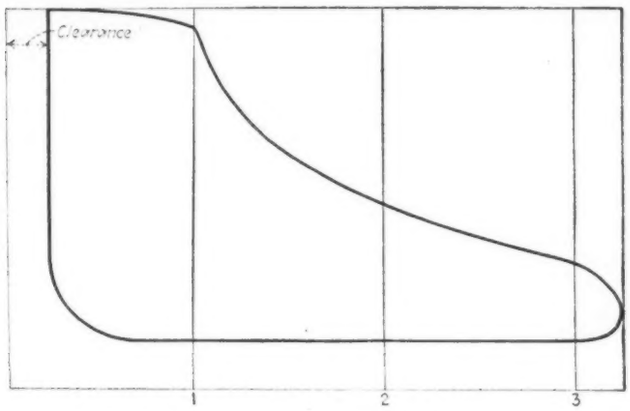


FIG. 4. CONSTRUCTING PV = CONSTANT CURVE

per unit of time to keep up that pressure effect. Now imagine the partition to disappear, the space to the left of the partition having been a perfect vacuum, and the volume to be doubled. The molecules that were traveling lengthwise of the cylinder have twice as far to go, so that if their velocity (temperature) remains constant they can hit only one-half as often. The molecules traveling crosswise of the cylinder have twice as much surface to cover and at the same speed can hit each unit of area with but half the frequency, so that when the volume is doubled the pressure effect is halved if the velocity of the molecules—that is, the temperature—is kept constant.

The temperature of expanding steam does not remain

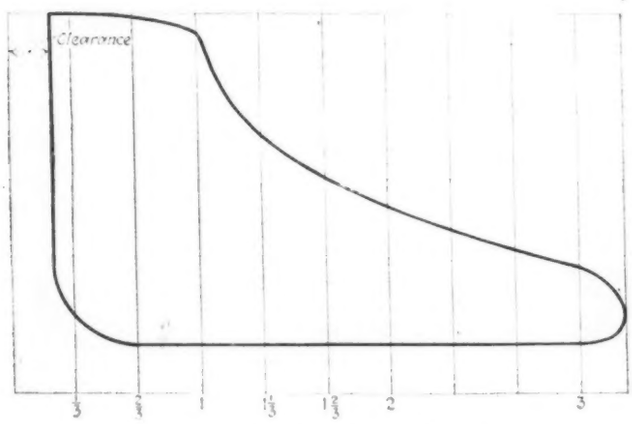


FIG. 5. PV = CONSTANT CURVE

constant, but for reasons that will be explained later, the expansion line of the ordinary indicator diagram follows quite closely this pv = constant curve. For this reason and because it is of importance in analyzing diagrams from steam engines and air, ammonia and other compressors, the user of the indicator should know how to lay it out upon a diagram.

The transparent chart which appears as a special supplement of this issue enables this to be done very easily if one knows the clearance of the cylinder from which the diagram was taken. Draw the clearance and absolute zero pressure lines upon the diagram as directed in the article on "Using The Indicator," *Power*, Feb. 14. Place the transparent chart over the diagram with the axes of the curves over these clearances and zero pressure lines and transfer the curve to the diagram by pricking with a needle point through the curve which passes through the point of cutoff. If none of the curves passes precisely through this point, prick in the curve as indicated by the adjacent lines.

But one does not always have a transparent chart at hand, and it is well to be able to lay out the curve by construction or computation. This can be easily done by erecting ordinates upon the diagram, as in Fig. 4, the first ordinate 1 passing through the point of cutoff and the others being spaced successively, the same distance from each other that the first is from the clearance line or line of zero volume. The numbers of the ordinates will then represent the successive volumes and the pressures upon the several ordinates may be computed by dividing

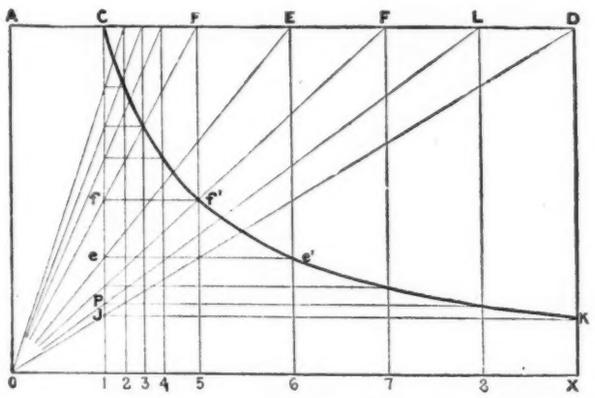


FIG. 6. GRAPHICAL CONSTRUCTION OF PV = CONSTANT CURVE

Construct rectangle equal to the diagram plus clearance in length and to the pressure in height. Erect ordinates 1, 2, 3, etc., as shown, starting with ordinate 1, passing through *C*, the point of cutoff. Draw the diagonal *OD* and at the point where it cuts the ordinate 1*C* draw a line *JK* parallel with the vacuum line *OX*. The intersection of the line with a perpendicular dropped from *D* is one point on the desired curve. Similarly from *L*, draw a diagonal to *O* and at the intersection *P* with 1*C* construct a line parallel to *OX*, and the intersection of this line with the ordinate *LS* gives a second point on the pv = constant curve.

the pressure upon the ordinate that passes through the point of cutoff by the number of the ordinates upon which the pressure is required. This can be handily done with the upper slide rule in Fig. 3 by inverting the slide as shown. Set the index of the *B* scale to the initial pressure on the *D* scale and opposite the given volume on the *D* scale read the required pressure on the inverted *C* scale. The scale in Fig. 3 is set for an initial pressure of 150 lb. on the *D* scale and opposite 2 on this scale as indicated by the hair line the pressure on the *C* scale is 75. The pressure on ordinate 5 on the *D* scale is shown on the *C* scale to be 30 lb., etc. There is a slide rule called the Duplex (shown as the lower rule in Fig. 3) which has upon the back of the ordinary slide a reversed scale in the use of which the two scales are contiguous and the numbers right side up. This rule probably is easier to read than the first one.

Having located the points upon the several ordinates, a smooth curve is drawn through them. With a comparatively late cutoff there may be too few ordinates to enable this to be done easily. In this case divide the horizontal distance between the clearance line and the

point of cutoff into a number of equal parts (2, 3 or 4 for example) and erect ordinates upon the diagram at the distance of one of these divisions apart. In Fig. 5 this has been done by making the ordinate spacing one-third the distance out to cutoff. The volume at cutoff is 3 of these smaller units of volume, and the ordinate passing through the point of cutoff is numbered 3, the following units being numbered consecutively.

The pressure upon each ordinate may be calculated by the following rule:

Multiply the absolute pressure upon the ordinate passing through the point of cutoff by the number of that ordinate and divide by the number of the ordinate for which the pressure is sought. The quotient will be the pressure upon that ordinate.

This rule applies equally to the case shown in Fig. 4, where the ordinates are spaced the full distance to the point of cutoff, the multipliers in this case being unity.

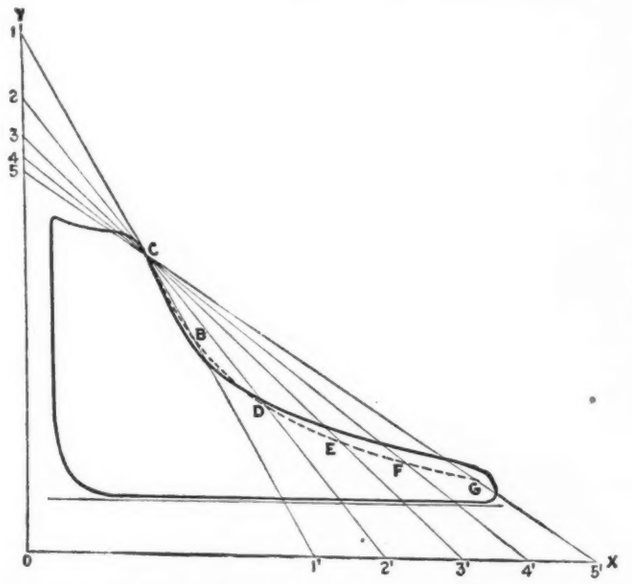


FIG. 7. A SECOND METHOD OF CONSTRUCTING *PV* CURVE

Erect the clearance line *OY* and the vacuum line *OX*. Through *C* the point of cut-off draw a line 1*C* and extend it to 1', the intersection with *OX*. Using a pair of dividers, lay off from 1' the distance 1'*B* equal to 1*C*. The point *B* will be on the *pv* constant curve. Draw other lines 2*C*, 3*C*, etc., and lay off from 2' the distance 2'*D* equal to 2*C*, locating a second point on the curve. This is followed for as many points as desired, and a smooth curve is then drawn through the points so located.

The results for this case retaining 120 absolute for the initial pressure would be as follows:

Vol.	×	Pres.	=	Constant	Vol.	×	Pres.	=	Constant
3	×	120	=	360	8	×	45	=	360
4	×	90	=	360	9	×	40	=	360
5	×	72	=	360	10	×	36	=	360
6	×	60	=	360	11	×	32.7	=	360
7	×	51.4	=	360	12	×	39	=	360

The slide rule can be used for this computation as before by seting the index of the inverted slide to the constant; that is, to the product of the pressure and the number of the ordinates at cutoff, 360 in this case. Figs. 6 and 7 show methods of laying out the *pv* constant curve graphically.

If the expansion line of the diagram were a true *pv* constant curve, the line of zero volume—that is, the clearance line—could be found by the process indicated in Fig. 8.

The point at which expansion must begin in order that the *pv*=constant curve may pass through a given point, may be determined by the construction shown in Fig. 9.

It will not be necessary to lay out the expansion curve very frequently. The user of the indicator will soon become familiar with the ordinarily correct curve and able to detect at sight any considerable departure from it, but it is well for him to be able to apply the ideal

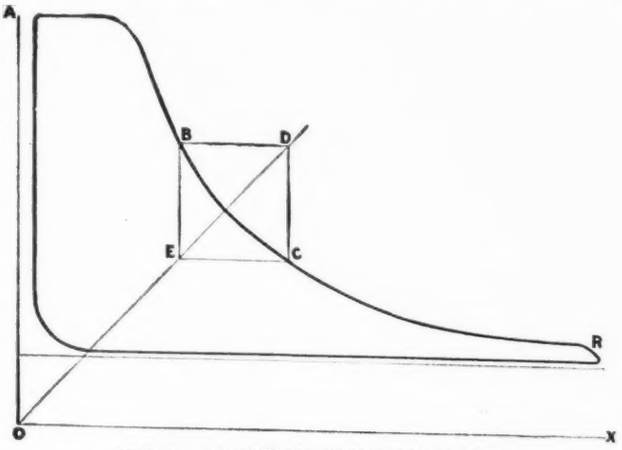


FIG. 8. LOCATING CLEARANCE LINE

At any two points on the curve, as *B* and *C* construct a rectangle having the base *EC* parallel to the vacuum line *OX* and the sides perpendicular to *OX*. Draw *DO* through the points *D* and *E* and the point *O* at which this diagonal cuts the vacuum line *OX* is one point on the zero volume of clearance line. *OA* is then drawn perpendicular to *OX*, giving the required clearance line.

curve in order to indicate such departures and interpret them in the light of the conditions. It is evident that a leaky steam valve would tend to make the curve rise higher than it should if the valve were tight, while a leaky piston or exhaust valve would tend to make it run

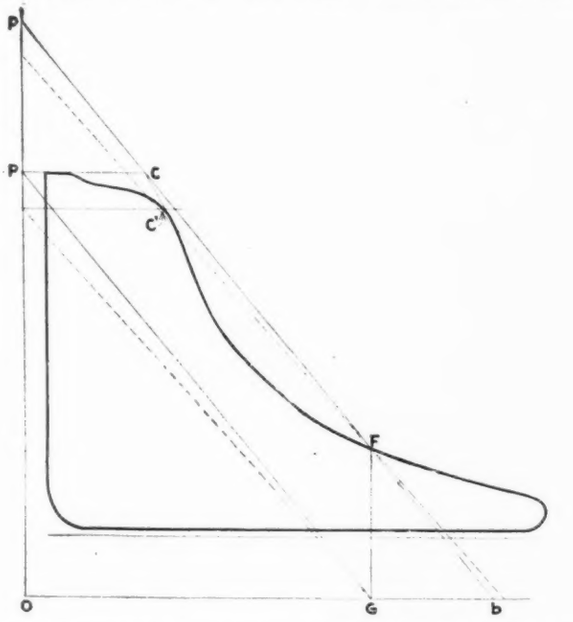


FIG. 9. FINDING BEGINNING OF EXPANSION WITH ANY GIVEN INITIAL PRESSURE

Drop a perpendicular from any point on the expansion to curve as *F*, and from its intersection *G* with the vacuum line *OX* draw the line *GP* intersecting the clearance line at a point *P* on a horizontal plane with the maximum pressure shown on the diagram. A line *bp* parallel to *GP* and passing through the point *F* is next drawn. This line will cut the horizontal line *PC* at the required point at which the expansion must begin to pass through *F*. This may be obtained likewise for any other pressure as shown by the dotted lines giving *C'*.

lower. Produce this latter condition by leaving the cylinder drains open more or less and while the diagram is being taken, and see what the effect is upon the relation of the actual expansion line to the *pv*=constant curve.

If you know that an admission valve leaks or can produce that condition, notice the effect when steam is thus admitted during expansion compared to that when the valve is tight or no steam is allowed to get in after cutoff. Familiarity with such causes and effects may help you to detect, by the use of the indicator, defects that would not be apparent to the less-trained observer. But it must be appreciated that the pv=constant law is not the natural law of the expansion of steam, that the coincidence with it of the actual expansion curve of the diagram from the ordinary engine is due to complications of the simple process of expansion, by the fact that what is being expanded is usually not pure steam but a mixture of steam and water, and by heat interchange between the operating medium and the cylinder. Departures from the pv=constant curve may therefore be due to other causes than leakage, and we shall consider in the next article the law of expansion of steam uncomplicated by such influences and the processes by which the expansion curve of the actual diagram is made to approach the pv=constant curves.

The Craig Damper Regulator

The position of the damper is controlled by a piston *F*, to which it is connected as shown in Fig 2. The weight *I* is sufficient to overcome the weight and friction of the piston and other connected parts, so that its tendency is to move the damper toward its open position. Water under pressure is admitted to the top of the cylinder through the slightly opened valve in pipe *H* and tends to depress the piston, with a resulting movement of the damper toward the closed position.

A series of ports *G* connects the interior of the main cylinder with a small cylindrical chamber beside it, the connection being opened or closed by the valve *C*, which consists of a rod sliding in this small chamber

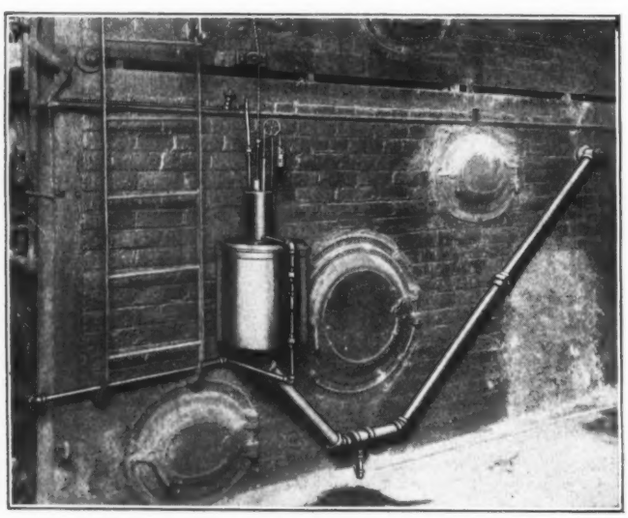


FIG. 1. REGULATOR AS INSTALLED

in the cylinder wall. When the piston in its downward movement reaches a level sufficiently below that of the lower end of the valve *C*, it uncovers one of these ports and the water is released to the small chamber and discharged through the outlet pipe. The pressure being thus relieved, the downward movement of the piston and the closing movement of the damper are arrested.

The interior of the bell-float *A* is connected through the pipe *B* to the boiler furnace. If, in a given position of the damper, the vacuum is greater or the pressure less than that which the regulator is set to maintain, the float will be drawn downward, carrying with it the valve *C*, closing the port, restoring the

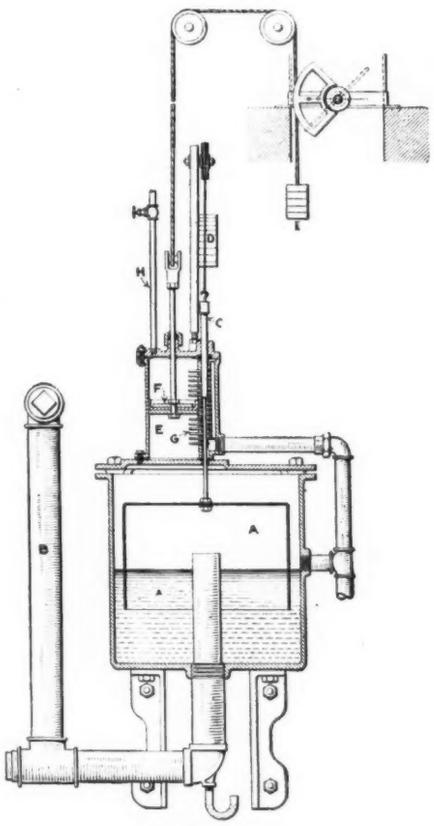
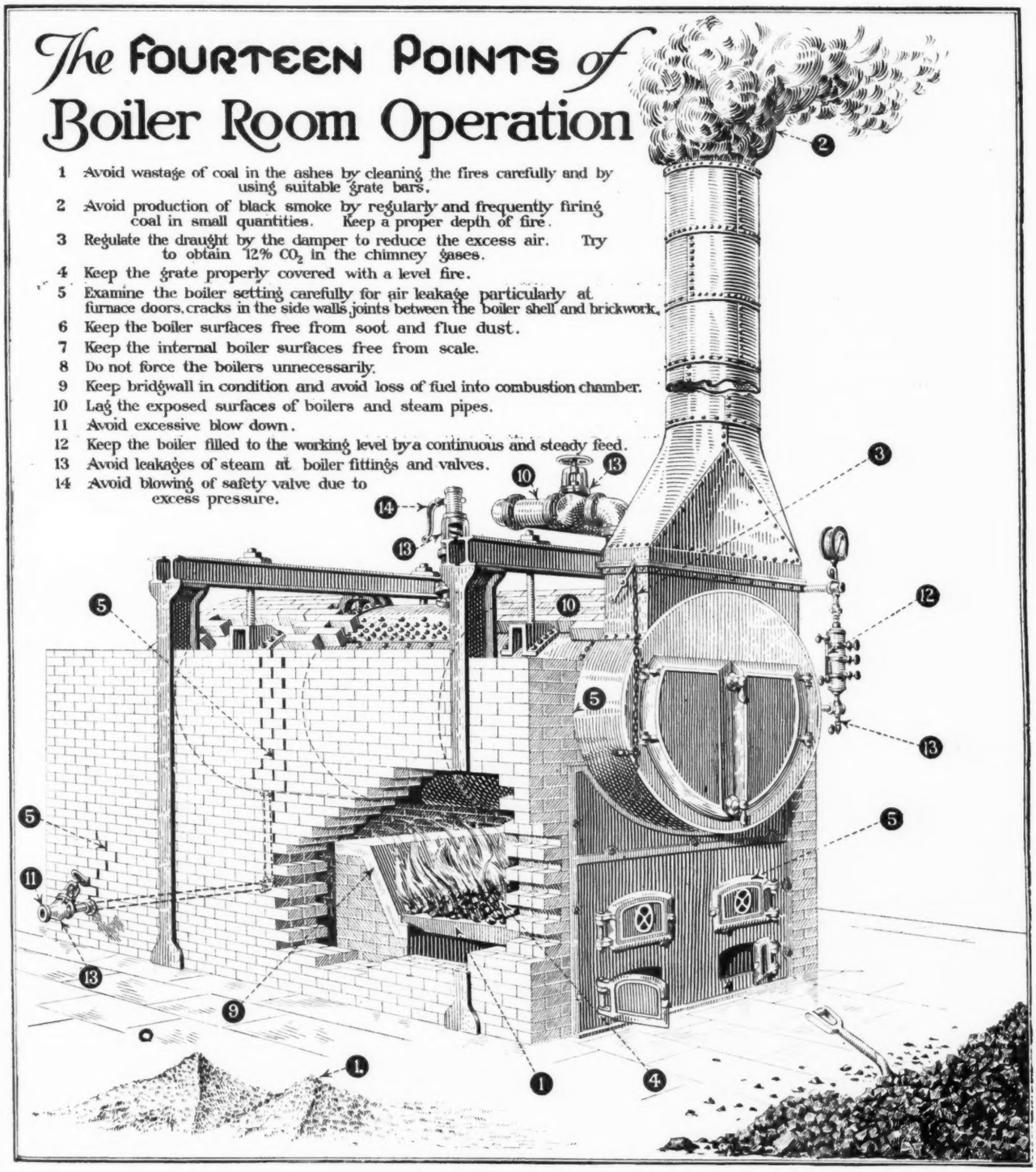


FIG. 2. SECTIONAL VIEW OF THE REGULATOR, SHOWING PRINCIPLES OF OPERATION

hydraulic pressure and causing a further depression of the piston and closing of the damper until that position of the damper that will just maintain the desired furnace pressure is found. This pressure may be adjusted for any desired amount by adding to or taking from the float counterweight *D*. A high degree of sensitiveness is attained by using a sufficiently large bell float, and it is claimed that with the apparatus as furnished a variation of not to exceed two-hundredths of an inch of water pressure may be secured.

The arrangement of multiple ports gives an advantage in operation by opening the damper quickly and closing it slowly. If a sudden pressure over the fire raises the bell float and valve *C*, several ports are uncovered and the water escapes quickly, allowing the piston controlling the damper to move upward rapidly. But if *C* moves downward, the small flow of water allowed to enter the cylinder closes the damper slowly, so that excessive pressure is not built up over the fire.

A uniform water level in the float chamber is maintained by connecting the chamber to the discharge pipe as shown. The regulator is shown in Fig. 1 as connected up for operation. The device is manufactured by the Craig Damper Regulator Co., of Detroit, Michigan.


The FOURTEEN POINTS of
Boiler Room Operation
1 Avoid wastage of coal in the ashes by cleaning the fires carefully and by using suitable grate bars.
2 Avoid production of black smoke by regularly and frequently firing coal in small quantities. Keep a proper depth of fire.
3 Regulate the draught by the damper to reduce the excess air. Try to obtain 12% CO_2 in the chimney gases.
4 Keep the grate properly covered with a level fire.
5 Examine the boiler setting carefully for air leakage particularly at furnace doors, cracks in the side walls, joints between the boiler shell and brickwork.
6 Keep the boiler surfaces free from soot and flue dust.
7 Keep the internal boiler surfaces free from scale.
8 Do not force the boilers unnecessarily.
9 Keep bridgwall in condition and avoid loss of fuel into combustion chamber.
10 Lag the exposed surfaces of boilers and steam pipes.
11 Avoid excessive blow down.
12 Keep the boiler filled to the working level by a continuous and steady feed.
13 Avoid leakages of steam at boiler fittings and valves.
14 Avoid blowing of safety valve due to excess pressure.

Boiler-Room Operation

That thousands of boiler plants are being operated inefficiently engineers will agree. The loss that occurs in these plants, although individually the inefficient plants are of small size, amounts to several millions of tons of coal per year.

The difficulty seems to be due not so much to indifference on the part of the firemen as to their lack of proper appreciation of the value of correct firing, tight settings, workable dampers, etc.

In the illustration above an attempt has been made to point out the most important factors that largely determine the results secured in the boiler room. If the fireman or the engineer will take this chart as a guide and go over the boiler, checking the conditions at the points enumerated and correcting any defects, the improved efficiency will be surprising.

The operation of a boiler is by no means simply manual work, but calls for the closest of attention on the part of the fireman. If, by following the suggestions enumerated in the chart, an increase of only one per cent were secured, the total annual saving would be appreciable.

Overhauling Storage Batteries

Symptoms That Give Warning of the Need of Overhauling—Preparation for the Work with Explicit Directions Covering Two Methods of Procedure, One To Be Used When the Work May be Carried Along to Completion, and the Other Where Interruption Is Probable.

BY CHESTER SCHENCK

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IN SPITE of the best care that can be given it, a storage battery must be overhauled sooner or later. Theoretically, the chemical reactions on which the performance depends may be perfectly reversible, and if nothing were lost in the process, there should be no depreciation during successive cycles of charge and discharge. Practically, however, the battery deteriorates with continued use.

A storage battery, such as is used to operate remote-controlled oil switches, is particularly subjected to conditions that are gradually injurious. It must be kept nearly charged at all times to insure plenty of reserve capacity when transmission-line trouble occurs and oil switches must be operated without delay. This prevents the battery receiving the full benefit of the allowable range of charge and discharge. For long periods it must stand on practically open circuit, then be required to furnish instantaneous discharges of many times the normal rate for that type of battery. Neglect or lack of care will hasten the damage unnecessarily, and the battery will become increasingly weaker, unless attended to before it practically ceases to function.

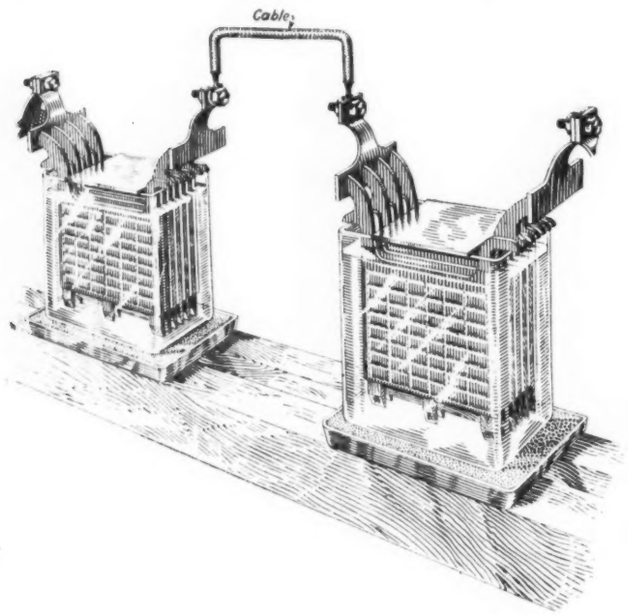


FIG. 1. CELL REMOVED AND "JUMPER" IN PLACE

Many symptoms give warning of the need of overhauling. Sediment, made up of particles of active material and of impurities such as flakes of lead sulphate dislodged from the plates, accumulates in the bottom of the cells and sometimes piles so high as to touch the plates. Charging is required almost constantly, yet the specific gravity is unusually low and cannot be brought up to normal even by extended overcharges. There is usually a wide variation between the readings of the several cells. The voltage falls unduly on discharge, and individual voltage readings of some of the cells when fully charged are considerably lower than the rest. Buckled or cracked plates may exist and there may be too much shedding of active material. Separators may be broken and out of place, and occasionally a sort of brownish "mush" collects between the lead terminal lugs where they hang over the edges of the cells. If neglected, the outside of the glass will become covered with acid spray, and the sand in the trays will probably be soaked with it. It may be possible to get an electrical shock from any part of the cell jar or plates because of the leakage path established to ground. Sometimes the wood supporting racks are badly acid eaten or decayed.

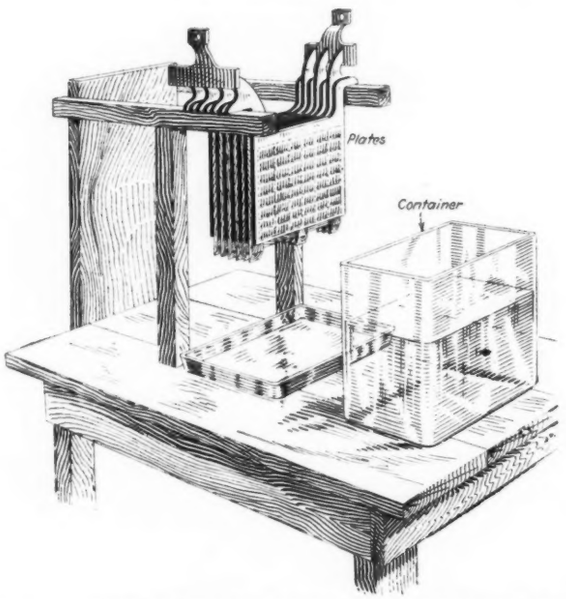


FIG. 2. CONVENIENT RACK FOR SUPPORTING PLATES WHILE OUT OF JAR

Storage-battery overhauling is usually put off as long as possible; oftentimes too long. The deterioration is so prolonged that if the operator is unfamiliar with the symptoms, he may be unable to determine even approximately when the work should be started. The importance of the battery sometimes seems so great that it is deemed impossible to spare any of the cells long enough for repairs to be made. After matters have been allowed to drift along until the battery refuses to operate longer, the job is undertaken.

The results of such deferred overhauling are likely to be disastrous. The work is almost sure to be done hastily because of the emergency that has been allowed

to arise, and probably in a careless manner, too. Ordinary repairmen, not particularly skilled in battery work, may be used, and owing to ignorance the work may be interrupted frequently. The possibility exists that some operations will be stopped indiscriminately at any time, when they should have been carried through to a proper stopping place, which would obviate injury to the cell material. There is a tendency to "skimp" the initial charge of overhauled cells because of the long time required.

The exact method of procedure will depend on the facilities available, and whether the work is to be done at odd times with frequent interruptions or to be followed up continuously until completed. It will depend also upon the extent of the job; whether only a few of the cells in the worst condition are to be renewed or the whole battery gone over.

When convenient working conditions can be arranged and it is fairly certain that the work can proceed rapidly and continuously to completion, the first method described later may be advantageously used; but if the work is liable to be interrupted, or if plates must be replaced, it is better to use the second method, even though it is longer and more tedious. The plates can then stand for a few days, if necessary, without injury.

A clean, well ventilated spot near the battery room should be chosen where there is sufficient space to work on the cells conveniently, and out of the paths customarily traveled in the normal operation of the station if possible. It should be away from metal structures, machines or other objects which would be injured by

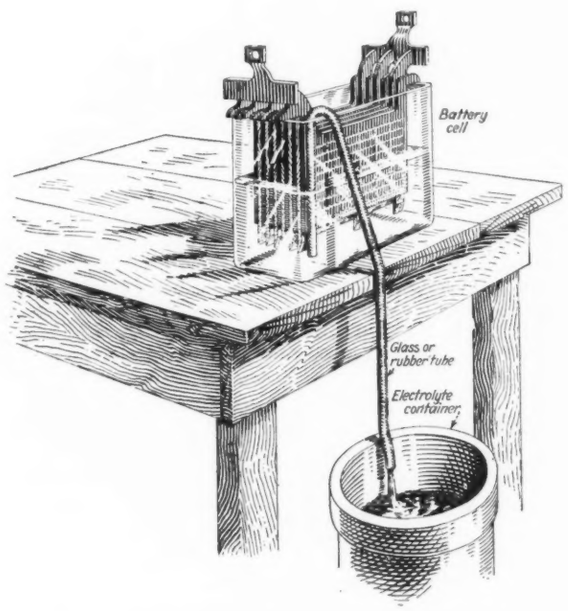


FIG. 3. SIPHONING ELECTROLYTE FROM A CELL

acid fumes, accidental splashes or spilled acid; or protection from the acid be provided. A table or workbench or even a strong box overturned should be made ready and a supply of fresh water of cleansing purposes be available.

Before the work is started it is essential to get together all the material and tools that will be required. The charging rheostat, if needed, should be constructed beforehand and the charging connections made. Experiments may be made on the first group of cells disconnected, before they are dismantled to see if they can be charged with the equipment as arranged, and to avoid delay when ready to start the charge. Make sure that there is an accurate hydrometer and a good thermometer available.

If any of the cell material seems to need replacing, the new material must be ordered and received before starting the work. One or two extra cell jars are con-

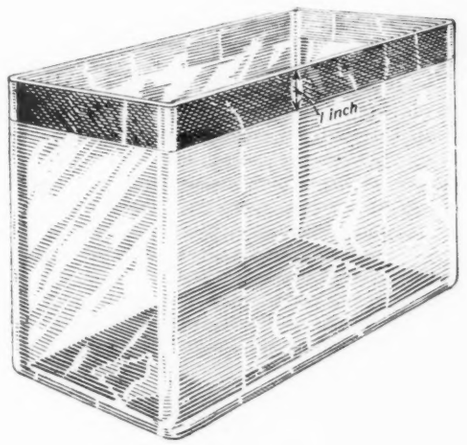


FIG. 4. PARAFFIN BAND AROUND TOP OF JAR TO PREVENT ACID CREEPING

venient and may be necessary to replace a broken one. Sometimes all the wooden separators, or the positive plates, or both, must be renewed. It is well to have some new separators on hand anyway. A few of the special connecting bolts with lead-covered heads and nuts should be obtained. Pure sulphuric acid of 1.4 specific gravity or higher should be procured for mixing new electrolyte and correcting the specific gravity of the old. Some strips of strong webbing from 4 to 6 in. wide will be useful for lowering the groups of plates back into the cell jars. Several containers for acid, such as stoneware jars of two or three gallons capacity each, or of whatever size it is thought to be convenient to handle, will be needed. A small pitcher or large mug may be used for handling limited amounts of liquid. Clean, dry sand will be required for filling sand trays. Other miscellaneous articles needed are aqua ammonia for neutralizing acid on skin or clothing, or baking soda to be dissolved in a bucket of water, or both, one or more pairs of goggles to wear while pouring acid, a brush and some paraffin to apply hot in a band around the outside of the cell jars at the top, a small bottle of olive oil for possible splashes of acid into the eyes, and an outfit of old clothing, wool if possible, for each workman.

Enough fresh electrolyte should be prepared beforehand to fill the cells which it is proposed to cut out first. Electrolyte is prepared by pouring pure sulphuric acid of high specific gravity into distilled water, stirring the mixture all the time with a clean wooden paddle, until the specific gravity is about 1.210. This must be done slowly and carefully, because the liquid gets hot and may spatter acid. The acid must always be poured into the water; never the water into the acid. A mixture of one part of 1.84 sp.gr. sulphuric acid to three parts of distilled water by volume will result in approximately the correct specific gravity. After the mixture has been allowed to stand and cool, it will be necessary

probably to add carefully either a little more water or acid to bring the specific gravity to exactly the desired value. Electrolyte should be mixed in a vessel that will not be affected either by the heat produced or by the acid. An earthenware crock or glazed jar, or a new wooden wash tub that has not been used previously for any other purpose, is suitable for mixing, but the electrolyte must not be allowed to stand long in the wooden receptacle. Never mix electrolyte in the glass battery-cell jars.

Whichever method of overhauling is contemplated requires that the entire battery be given a full charge just previous to beginning the work. The battery is then disconnected from the charging sets and from the control bus, and the desired cells are cut out. This is done by unbolting the lugs on each side of the particular cells and carefully lifting them and their sand trays down from their places on the rack. Be careful not to accidentally short-circuit either the cells being removed or any of the others, while working around them. Such short-circuits are vicious and are liable to burn the workman, as well as damage the cell. "Jumpers" of heavy wire or cable, which have been made ready previously, are quickly bolted in place between the lugs where the cells have been removed, as indicated in Fig. 1, and the battery connected to the control bus again, so as to be back in service without unnecessary delay. From five to seven cells are all that it is well to undertake at any one time, as otherwise the voltage of the remainder of the battery may be too low for the control bus.

It is well to clean off the portion of the battery rack where the cells have been standing, let it dry if necessary and give it a good coat of acid-proof paint or varnish, as soon as possible. A second coat should be given it later, and possibly a third if it seems advisable. If portions of the racks are decayed or broken, it may be necessary to remove all the cells and make more extensive repairs.

Overhauling When Work Can Be Completed Without Interruption

Carefully lift the group of plates from a cell, pressing them together with the hands to avoid displacing the wooden separators, and hang them by the plate lugs on a rack made of two strong pieces of wood supported at the same distance apart as the edges of the cell, as in Fig. 2. Pour the clear part of the electrolyte from the cell jar into one of the stoneware containing jars which has been washed thoroughly clean, taking care to disturb the sediment as little as possible. Empty the sediment into another container and wash the cell jar carefully. Examine the group of plates, remove any loose active material from them, scrape away any "mush" that has collected between the hanging lugs, and replace any broken or defective separators. Lift the group of plates back into the clean jar and immediately fill it with the fresh, cool electrolyte, which was previously prepared, before the plates have a chance to dry. The work must be done quickly and without stopping, because of the rapid drying as the negative plates will become hot and be damaged if exposed to the air too long. If a spare glass cell jar is available, it will save time to clean it and lift the plates from one cell, inspect them while they are being held and then place them directly into the clean jar.

Empty the sand tray, wash it clean and fill it with clean, dry sand. Set the newly filled cell in the center of the tray and level it carefully. Proceed in the same manner with each cell removed, and then connect them together temporarily as a battery, and give them a long charge, as described later.

Longer Method That Will Permit Interruption

Siphon the electrolyte into clean containing jars, as in Fig. 3, being careful not to disturb the sediment. As soon as each cell is emptied, fill it with fresh, pure water. The siphon may be made from glass tubing with the opening of $\frac{3}{8}$ or $\frac{1}{2}$ in. diameter and the short leg of sufficient length to reach to the bottom of the cells. It may be started by filling the siphon full of electrolyte, holding a finger over each end until the end of the short leg has been immersed under the surface of the liquid in the cell. Let the cells stand full of water for twelve or fifteen hours. They should be watched, or if they are to stand over night, arrangements should be made with the night station attendants to watch them, and if the

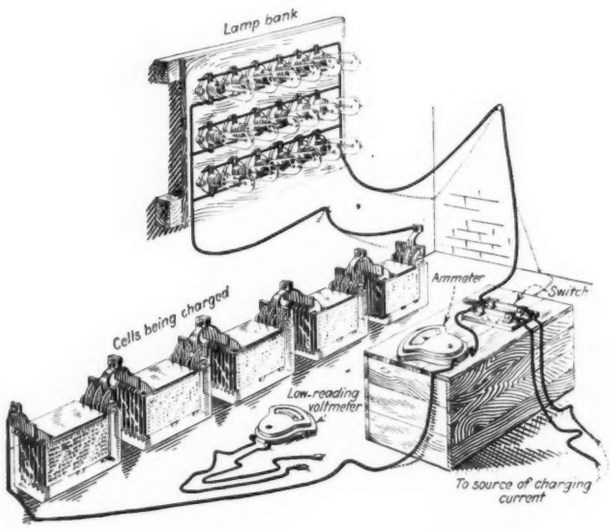


FIG. 5. CHARGING OVERHAULED CELLS

cells show a tendency to heat up, cold water should be added to keep the temperature less than 100 deg. F.

The groups of plates may then be taken from the cells when ready, separators be removed, damaged ones thrown away, and the usable ones saved and preserved for use by completely immersing them in a weak acid solution made from electrolyte of 1.210 sp.gr. added to nine or ten parts of water. The positive and negative groups of plates should be carefully pulled apart, washed with running water and thoroughly inspected. "Buckled" plates may be straightened and groups containing cracked or broken plates be separated from the rest. If it is thought desirable to replace one or more plates of a group, the new plates should be joined to the connection strip by the process of "lead burning." Sometimes it is better to replace positive plates which are badly sulphated or which have lost much of their active material than to attempt to charge them long enough to put them in condition. This is a matter of individual judgment. The plates may be allowed to dry and the cells be reassembled whenever convenient. When ready to do so, the process is exactly the same as for setting up new cells.

Be thorough in every operation. Keep all the materials and the working place clean. Do not allow anything to get into the cells that does not belong there. The

slightest trace of some substances is hurtful. Work methodically and rapidly, but not hastily.

Covering any exposed metal parts such as copper terminal lugs with vaseline will protect them from the acid. It is well to apply a band of melted paraffin with a brush around the outside of the cells at the top, as in Fig. 4, to help prevent the acid from "creeping" over the edge and collecting on the outside of the glass.

The used electrolyte, which is saved from the first cells overhauled by either method, is brought up to the normal specific gravity of 1.210 by adding sulphuric acid as previously described. It is used to fill the next group of cells overhauled, just as fresh electrolyte was used in the first group. Additional fresh electrolyte must also be provided because some must be added to fill the space previously occupied by sediment in the cells. Any used electrolyte suspected of containing metal or other injurious impurities should be thrown away.

Immediately after each group of cells is reassembled and filled with electrolyte, the cells must be connected together temporarily as a battery and placed on charge without delay. It is well to have made the proper arrangements for obtaining and regulating the low voltage necessary for charging a few cells before undertaking to overhaul them. Unless the generator is of special design, it will probably be necessary to construct some sort of a rheostat to bring down the generator voltage to the point desired.

Current-Carrying Capacity of Rheostat

The rheostat must have a current-carrying capacity for the full ampere charging current. It must absorb the difference of voltage between that of the generator and the few volts necessary for the cells. Such a resistance may be constructed of iron wire of proper size and length, wound on a wooden frame which has been covered previously with sheet asbestos, but it must be carefully calculated, and is bulky and expensive to make.

Probably the safest and most satisfactory rheostat is a bank of lamps. Fifteen 32-cp. carbon lamps connected in parallel will take approximately 15 amperes. A 100-watt lamp takes about 0.8 ampere at 120 volts, so that about 18 of them in parallel will be required to take 15 amperes. Lamps of any size can be used if the proper number are connected in parallel to take the desired current value.

As indicated in Fig. 5, the charging connections need not be complicated. A double-pole knife switch should be mounted temporarily near the cells to be charged, and wires run from the switch to the generator main switch on the panel. The wires should be connected to the studs on the generator side of the switch. The charging circuit from the temporary switch should consist of the lamp bank or charging resistance, an ammeter of suitable range, and the cells to be charged all connected in series and to the switch. The cells must be joined together so that the positive terminal of one connects to the negative terminal of the next, and the positive terminal of the group must connect to the positive generator terminal. A low-reading voltmeter should be provided to read the voltage of each separate cell at intervals during the charge.

To start the charge, the charging generator is started and the generator voltage adjusted to about 120 volts. The temporary switch should then be closed. The ammeter will indicate the current flowing, and it may be necessary to raise or lower the generator voltage somewhat to bring the current to its proper value. The generator voltage will need to be adjusted from time to time as the charge progresses, to maintain the charging current at its normal value as the cells become fully charged.

If the lamps burn too brightly so that they seem likely to burn out when the current is at the proper value, it may be necessary to connect up one or more additional lamps, but if the current taken is too high, the remedy is to unscrew one or more lamps from their sockets until the correct value is obtained.

Starting the Initial Charge of the Overhauled Battery Cells

The initial charge of overhauled cells should start immediately after they are filled with electrolyte, and charging must be continued without interruption until the voltage and specific gravity of all cells have been at a maximum for 5 to 10 hours, and all cells are gassing freely. A total charging time of 35 hours or more may be required, but the aim must be to continue until the indications of complete charge are satisfactory rather than to charge for any given length of time. It pays to be generous with this first charge. After the charge is finished and the cells allowed to cool, the specific gravity of each cell should be read and adjusted, if necessary, so as to be between the limits of 1.205 and 1.215.

Before returning the cells to their places on the rack, scrape both sides of each lug. See that the main battery is fully charged, so that all cells will start off in the same condition. Then disconnect the battery from the control bus, remove the temporary jumper, carefully set the overhauled cells back in their places so that the positive lugs will be next to negatives and negatives to positives of adjacent cells. Bolt the lugs together with the special bolts having lead-covered heads and nuts. If more cells are to be overhauled, they should be removed as previously described, and the battery connected to the control bus as soon as possible so that it will be ready for immediate service.

On account of much lower cost, hydrogen is sometimes used instead of acetylene in welding and cutting torches. Aside from the fact that it is a little slow in heating up the material, hydrogen gives practically as good results as acetylene when it comes to cutting, but in welding iron and steel it is hardly satisfactory. This is due to the fact that the flame temperature is low and it is difficult to melt any appreciable thickness of metal. For welding aluminum or bronze the oxyhydrogen flame seems to have a certain advantage as its lower temperature is sufficient to weld these materials and at the same time produce a more diffused heat.

The following boiler-feed ratings are considered conservative by the Hydraulic Society for the sizes of duplex pumps enumerated. They are based on 34.5 lb. of water per 10 sq.ft. of boiler-heating surface per hour and are considered to be good practice and worthy of adoption:

	Heating Surface, Sq.Ft.		Heating Surface, Sq.Ft.
3 x 2 x 3	800	7½ x 5 x 10	10,600
4½ x 2½ x 4	1,800	9 x 5½ x 10	11,700
5½ x 3½ x 5	3,250	10 x 6 x 10	15,150
6 x 4 x 6	4,600	10 x 6 x 12	15,600
7 x 4½ x 8	6,800	12 x 7 x 12	21,250
7½ x 5 x 6	7,250	14 x 8½ x 12	31,400
7½ x 4½ x 10	8,450		

Efficiency of the Diesel Oil Engine

The Diesel Engine, Unlike All Other Prime Movers, Is Thermally More Efficient at Part Loads. Do You Know Why?

By L. H. Morrison

ONE of the things about the Diesel oil engine which occasions a good deal of speculation among operating engineers, is its fairly uniform efficiency at all loads. The fuel consumption per brake horsepower at full and that at one-half load differ by

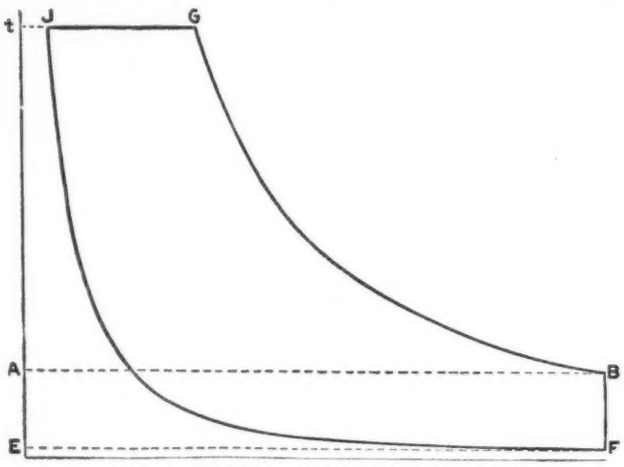


FIG. 1. DIESEL INDICATOR DIAGRAM

less than 10 per cent. Since the mechanical efficiency is not over 80 per cent, taking a 100-hp. engine as an example, the engine actually develops 125 indicated horsepower, the friction loss being 25 hp. With a fuel consumption of 0.45 lb. per b.hp., this is 45 lb. for 125 i.hp., or 0.36 lb. per i.hp. At one-half load the fuel consumption is 0.50 lb. per b.hp., or a total consumption of $0.50 \times 50 = 25$ lb. The friction loss is still 25 hp., the engine actually developing 75 hp. The fuel consumption per indicated horsepower is then $25 \div 75 = 0.33$ lb. The engine is actually more efficient thermally at low loads than at full load. This is in marked contrast to the steam engine, in which the thermal efficiency drops off quite sharply at low loads.

Diesel Indicator Diagrams

In Fig. 1 is shown an indicator diagram *FJGB* which is an ideal Diesel diagram. The introduction of fuel and its combustion is at a rate such that the pressure is constant, as indicated by the horizontal line *JG*. The expansion of the gases follows the curve *GB*, and the gases are expelled at the end of the stroke at *B*, the pressure dropping to *F*, or atmospheric pressure. The charge of fresh air is drawn in during the suction stroke (here omitted) at atmospheric pressure and is compressed along the curve *FJ*. The work done by the engine is proportional to the area of the diagram *FJGB*, and the heat lost through the exhaust in foot-pounds is proportional to the area *BAEF*.

The efficiency of any engine $= \frac{\text{Work output}}{\text{Heat input}}$, and since the input is equal to the work output plus the exhaust loss, assuming adiabatic conditions, the efficiency can also be set down as $n = \frac{\text{Work}}{\text{Work} + \text{Exhaust}}$.

Now let the load be made enough less than full load so that the heat lost with the new load, or the area *CDEF*, is just one-half of the heat lost during the full load diagram, or one-half of *BAEF*. The indicator diagram at this load would be *FJKC* in Fig. 2. We do not know the area of it in respect to the full-load diagram *FJGB*, and the efficiency cannot be found direct. However, since the efficiency $= \frac{\text{Work}}{\text{Work} + \text{Loss}}$ and the heat loss is one-half the full-load loss, if the diagram area is one-half the full-load diagram the efficiency at the two loads would be identical; if the low-load diagram is over one-half the full-load diagram, the low-load efficiency will be more than the full-load efficiency.

Now let us pass a vertical line *KO* through *K*, cutting the compression line *FJ* at *P*, Fig. 3; extend adiabatic expansion line *GB* until it intersects *KO* at *L*. Under ideal conditions the compression and expansion lines are adiabatic curves, indicating that no heat is lost through the cylinder walls. This being true, since $CF = \frac{1}{2} BF$ by construction, *KP* is one-half of *LP*. This is for the reason that the pressures on two or more adiabatics at any given volume have a ratio which also exists at any other volume.

Efficiencies at Full and Low Loads

If, at the point of compression *P*, a charge of fuel is ignited, causing a pressure rise to *L*, the heat added is the area *PLSR*, which is equal to the work done, the area *FPLB*, plus the heat loss *BAEF*. If a mixture on exploding raised the pressure to *K*, the heat added is the area *PKTR*, which is equal to the work done, *FPKC*, plus the heat lost, *CDEF*. Since the heat added in the first

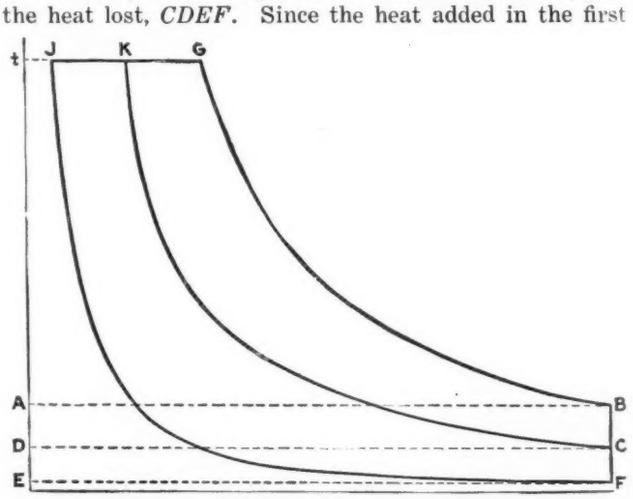


FIG. 2. DIAGRAMS FOR FULL AND PARTIAL LOADS

case is the area *PLSR*, which is twice the heat added in the second engine, or *PKTR*, and by construction the heat lost in the first case is twice the loss in the second engine, the work area *FPKC* must be one-half *FPLB*, or the diagram *FPKC* is equal to *CKLB*. The area *CKLB* is greater than *CKGB* and the area *FPKC* is less than the low-load Diesel diagram *FJKC*. It follows then, that the low-load Diesel diagram *FJKC* is greater than the

area *CKGB* and must then be greater than one-half the full-load Diesel diagram *FJGB*. This being true, the efficiency at the low load is greater than the efficiency at full load, for, as already pointed out, if with an exhaust loss of one-half the full-load loss, the efficiency

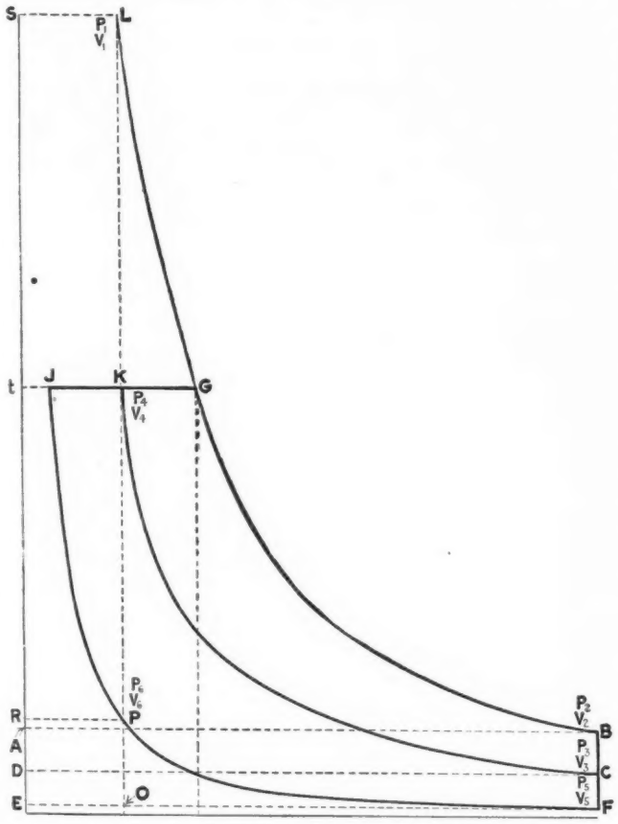


FIG. 3. DIAGRAMS SHOWING EFFICIENCIES

at the low load will be greater than the full-load efficiency if the low-load diagram area is over one-half the full-load diagram area.

What the Steam-Flow Meter Told

BY CORNELIUS G. WEBER

Recently, the writer has had occasion to conduct numerous tests on power plants equipped with reliable steam-flow meters, where it had become the routine merely to read the meters in the morning and file away the records without making any attempt to analyze them. One of the plants supplied light, heat and power to the building in which it was located, live steam for heating and other purposes to a large building about four blocks away and exhaust steam for heating to a third building. In both cases the condensate was pumped back to the power plant.

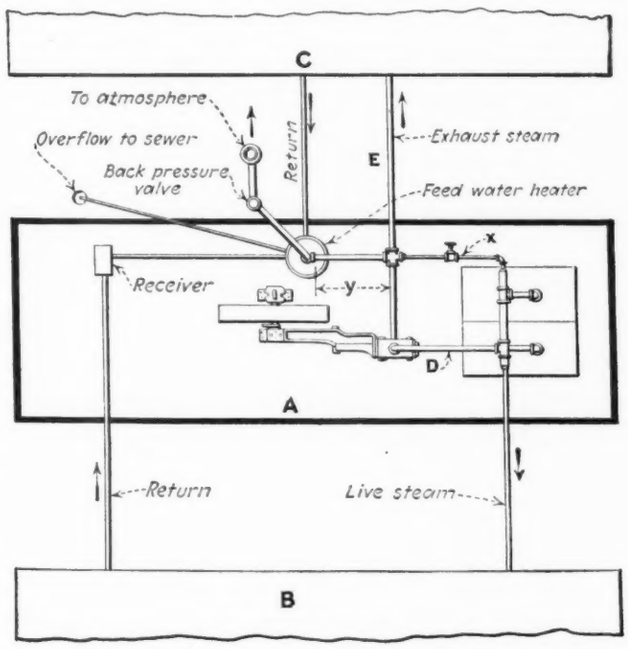
The general arrangement of the piping is shown in the sketch. As will be noticed, a live-steam line supplies building *B* from whence the condensate is carried back to a receiver in plant *A* and then pumped back into the feed-water heater. Another line supplies exhaust steam for heating building *C*, and the condensate is likewise pumped back to the feed-water heater in plant *A*. An auxiliary live-steam connection shown at *X* is available to supply building *C* in case of a deficiency of exhaust steam, but during the test this connection was shut off.

A portable steam-flow meter was first connected at *D*, and by taking a series of readings over a wide range of engine load, the water-rate curve of the engine was plotted. The meter was next connected at *E* to obtain the steam consumption of building *C*. While reading at *E*, it was noticed that the back pressure, as well as the rate of flow of steam, was irregular, and, more surprising still, that the flow of steam at *E* was greater at times than the amount of steam going to the engine. At other times the flow would fall below the steam consumption of the engine. Careful examination revealed the fact that no live steam was passing at *X* and that the flow meter was recording correctly.

With the flow meter showing a comparatively constant record during a given interval and with no exhaust steam being discharged to the atmosphere, an additional electric load was switched on the unit to increase the steam consumption. Inspection showed that no steam was discharging to atmosphere and that the flow-meter reading at *E* had not increased.

To reconcile the erratic readings, the entire system was inspected carefully with the following results: There were numerous leaky traps in building *B*, and at times a large amount of steam was passed along with the condensate. This steam sometimes flowed in such amounts that it caused a reversal in the direction of flow in the pipe *Y*; that is, part of the steam entering the feed-water heater from building *B*, flowed from the feed-water heater into the main exhaust steam system and was recorded at *E*.

An inspection of the feed-water heater showed that the float valve had been broken and that makeup water



ARRANGEMENT OF LIVE AND EXHAUST STEAM PIPING

was being fed in abnormal amounts. In fact, when a large load was being carried by the engine and when the heating system was not absorbing the extra steam, the overflow pipe from the feed-water heater was carrying this steam away to the sewer in the form of boiling water. Further tests conducted on the feed-water heater showed that the amount of boiling water discharged to the sewer corresponded to the equivalent of

about 100 tons of coal per month. Needless to say, steps were taken immediately to rectify these conditions.

The flow meters installed in the plant would have told the same story had they been moved about or additional meters installed to reveal the operation of all departments. Too many operators appear to be satisfied with one or two meters, installed permanently, from which they take the readings from day to day without attempting to strike a heat balance. Steam-flow meters are a blessing but they must be used with judgment, their readings analyzed and a sufficient number installed to tell the full story.

Adams Water-Tube Boiler

A new arrangement of the bent-tube boiler has been designed by R. J. Adams, of the Lasker Iron Works, Chicago. The primary object is to get the maximum surface in the first bank by using the longest tubes possible, set at the greatest inclination the headroom will allow.

An effort has been made to improve the efficiency by arranging the baffling to turn back the hot gases from the furnace and pass them downward along the tubes toward the mud drum, thus eliminating the comparatively cool film of gases otherwise adhering to the tubes. As the cooler gas is more dense, the tendency will be for it to move downward ahead of the hotter gases. The scrubbing action secured thus carries away the insulating films of cooler gas around the tubes, displaces them with hotter gases and tends to lessen the deposit of soot.

Both illustrations show the course of the gases through the boiler. The hot gases from the furnace pass upward through the tubes at the front of the bank, are turned back on the tubes by the baffling and follow the cooler and heavier gases down through the opening

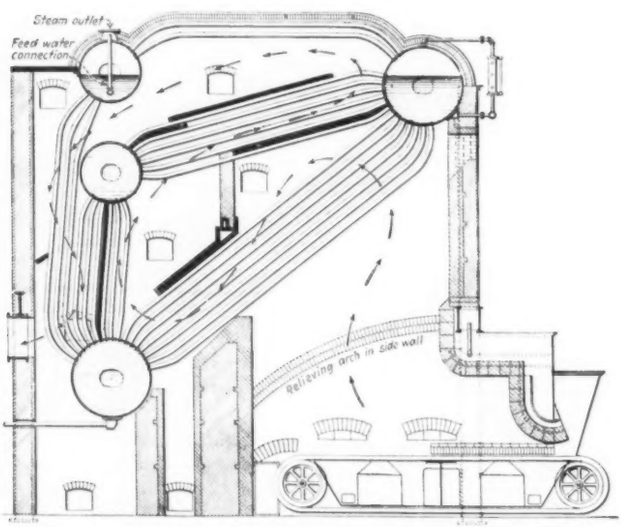


FIG. 1. ADAMS FOUR-PASS WATER-TUBE BOILER

into the second pass, according to the designer's claims, which are based on computations of the relative weights per unit volume of the gases before and after being cooled by contact with the tubes. From these calculations, it is argued that the hottest gases will not take the shortest path out of the first pass directly over the bridge wall, but rather will sweep up into the space at the front of the tubes as indicated by the arrows.

Both types of the boiler, as shown in the illustrations, have been designed to allow for comparatively low headroom without sacrificing full area for circulation and full surface for drying the steam. The drying tubes between the front and rear steam drums are in the direct flow of the gases, eliminating pockets and the danger of gas explosion. As the baffling is arranged to place these tubes in the third pass, they are in a zone

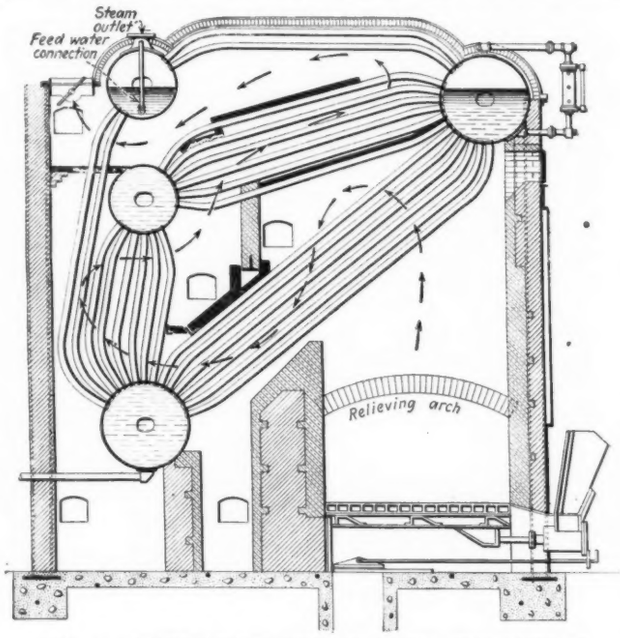


FIG. 2. THREE-PASS BOILER WITH TOP OUTLET

of comparatively low gas temperatures, where the service conditions are not severe. As the distance between steam drums is comparatively great, there is plenty of drying surface.

Another feature of the boiler is the arrangement of the water-heating surface so that the steam has two points of liberation. All the steam that is generated in the first bank of tubes directly over the fire is released into the front steam drum and is not obliged to go through a second bank of tubes before it may separate from the water. The steam generated in the upper bank of water-circulating tubes is carried back to the front steam drum through the top row of tubes in the bank, thus being discharged above the water line. The steam travels back through the drying tubes to the top rear drum from which it is drawn off to the superheater or to service.

Into this same drum the feed water is introduced, passing downward through the rear tubes to the mud drum. These tubes, therefore, act as an integral economizer. The makers lay stress on the fact that the feed is introduced into a drum not agitated by the circulation and at the same time steam is drawn from this same drum, the quietest part of the boiler.

The baffling arrangement may be varied to provide a top or bottom take-off for the gases, as desired. Fig. 1 shows a bottom take-off and a four-pass boiler, in which the rear tubes, through which the feed water passes first, have full economizer effect. Fig. 2 shows the baffling arrangement with a top uptake and a three-pass boiler. In either case all banks of tubes are readily accessible, the tubes themselves having been spaced, as usual, alternately wide and narrow along the drums to make removal easy.

Properties of Condenser Tubes*

Muntz and Admiralty Metals Discussed—Effects of Internal Strains, Crystalline Structure and Thickness of Tubes

AT THE present time there are two kinds of condenser tubes in commercial use—Muntz metal and Admiralty metal. The former, composed of 60 per cent copper and 40 per cent zinc, is cheaper to manufacture, since it can be worked either cold or hot; it is more susceptible to corrosion and, therefore, is used principally in fresh water that has a comparatively small content of corrosive elements. Admiralty metal is composed of 70 per cent copper, 29 per cent zinc and 1 per cent tin. It is used for salt and fresh water service where corrosive elements are present in appreciable quantities. Rivers that drain coal, zinc, lead or other mines are usually contaminated by sulphur or sulphuric acid; rivers that contain the waste from plate mills or chemical plants are subject to acid or alkaline impurities. There is no known commercial composition of the base metals that is impervious to circulating water containing such corrosive ingredients, but if Admiralty composition be employed and the metal be perfectly sound, free from defects, of maximum density, with smooth surface, free from strains and having a fine microscopic structure, it will be found that such tubes will give an unusually long term of satisfactory service even under unfavorable conditions.

Cracking of the tubes, or "season cracking," is a fault that sometimes arises. This is due to the internal strains left in the metal after the manufacturing process. Brass is naturally a ductile metal, but the processes of rolling or drawing it cold harden the material and usually leave unequal strains in the tubes. These internal strains eventually break down the metal unless they are removed before shipment from the factory.

Testing for Internal Strains

The condition of internal strain can readily be tested by means of the "accelerated corrosion test," which is used extensively by the United States Government. A short specimen of the tube is immersed for fifteen minutes in a 10 per cent solution of mercurous nitrate; 100 grams mercurous nitrate and 13 c.c. of nitric acid (sp.gr. 1.42). Internal strain will immediately produce season cracking in such a test. It is important to immerse the entire specimen, as otherwise the portion that is not immersed may tend to bind the entire specimen together and thus prevent the crack appearing. It is also important to use the bath for not more than fifteen minutes, as this solution would, in time, penetrate the tube itself.

Corrosion of condenser tubes is a fault that may be caused by the condition of the circulating water and that may be accelerated or retarded in accordance with the crystalline structure of the tube. One of the forms of corrosion is "dezincification," a symptom of which is a red spongy copper deposit somewhat resembling iron rust in appearance, but which is readily distinguishable from it with a little practice, and which appears on the water side of the tube. This is caused by one of the crystals known as the "Beta" crystal, in the composition of the tube, which has gone into solution as salts of copper and salts of zinc. The zinc salts, being soluble in water, are carried away in solution, while the copper is redeposited on the walls of the tube as a spongy red mass.

The standard method of testing condenser tubes is to flatten with a hammer. The tube should have a fine crystalline grain of a yielding consistency. The late J. P. Sparrow, formerly chief engineer of the New York Edison Co., who made an extensive study of condenser tubes, advised that the value of the tube is in direct relation to the fineness of the grain; in other words, the best tubes had the finest crystalline structure. These conclusions have been verified by other investigators, notably Mr. Woods, of Southern California.

Influence of Crystal Structure

Muntz-metal tubes are composed of two crystals, known as "Alpha" and "Beta" crystals, which make up the structure of the tube. The former crystal imparts the quality of cold ductility so that the manufacturing process may be carried on while the metal is cold. This is also the more resistant to corrosion and is, therefore, valuable to the metal on this account. When this metal is at red heat, the Alpha crystal becomes changed into the Beta crystal, but the Alpha may again be produced in the structure by reannealing at a lower temperature with the proper rate of cooling. The Alpha crystal composes Admiralty metal entirely.

The Beta crystal, while not present in Admiralty metal, composes Muntz metal largely. This imparts the quality of hot ductility, so that Muntz metal, which contains both crystals, may be worked either hot or cold. This crystal is subject to corrosion and on this account is less desirable in the finished product. The Beta crystal may be lessened in the structure by proper heat treatment and mechanical treatment in the process of manufacture. This crystal does not appear in Admiralty metal, so that the latter does not possess the quality of hot ductility.

How Muntz Metal is Made

Muntz metal was formerly manufactured by casting a small hollow cylinder and drawing it into a tube. This meant the danger of spongy metal due to gas from the core, as well as mold dressing becoming entrained in the metal. This process was improved by enlarging the mold so there was comparatively less gas and a proportionately larger body of metal. This larger volume of metal was slower in cooling and presented a greater pressure while in liquid form, which tended to force the gas more quickly to the top of the metal and thus assist in preventing entrained gas. Further improvement in this process consisted in eliminating the core entirely and casting instead, a solid cylinder of brass, which was hollowed by the "Mannesman Process," similarly to the way in which seamless steel tubing is made at present. In this process the cylinder is cross-rolled while red-hot, so that it revolves and tends to form a void at the cen-

*The information contained in this article was obtained through the courtesy of C. A. Gleason, of the Scovill Manufacturing Co., who was formerly an inspector of condenser tubes with the United States Navy and during the war was in charge of speeding up production on these tubes. He advocated the process of manufacturing Admiralty tubes from sheet metal that was perfected at the Waterbury plant of the Scovill company.

ter. Under these conditions a piercing rod is made to penetrate the axis, so as to form an even and regular void, or "bore." The hollow cylinder is now drawn into the required tube lengths. The original cylinders were 4 in. in diameter, with a core 2⅛ in. in diameter. The improved process used a cylinder 3 in. in diameter with no core. At the present time a solid cylinder of large diameter, weighing 750 lb., is used by the Scovill company, which takes full advantage of the principle of mass casting in order to produce a metal free from casting voids.

Short sections of this heavy cylinder are reheated and extruded into a solid bar of suitable size for the Mannesman machine, which converts them into hollow cylinders or shells. This double hot operation produces maximum density and a homogeneity of structure.

It is most important to maintain the proper relation between the cold work done in manufacturing on one hand, and the heat treatment, both preliminary and final, on the other hand. Annealing must be carried far enough to break up the crystals and produce the finest possible grain and to remove internal strains. When heat treatment is carried too far, crystal growth begins which results in coarser metal, weaker structure and susceptibility to rapid corrosion where salts or acids are in the circulating water.

Tin Produces Non-Corrosive Properties

Admiralty metal was developed originally by the British Navy and is standard for all marine service. Tubes for marine work were originally of Muntz metal covered with a coating of tin. This made the best possible non-corrosive covering, but when the coating became punctured, the corrosive action was extremely rapid on account of the electrolytic action due to the difference in potential between the tin and the brass. The tin content of Admiralty metal is most valuable on account of the non-corrosive properties that it produces in the metal. A larger percentage of tin would be more valuable for this reason, but is undesirable on account of the manufacturing difficulties of such a composition and the tendency to form oxides in melting.

Admiralty metal contains only the Alpha crystal and, therefore, cannot be worked while hot. The Mannesman process cannot be employed, and so these tubes are originally made by casting hollow cylinders and drawing into tube lengths as in the original process for Muntz metal. The same difficulties were encountered as in Muntz-metal manufacture, and an improvement on this process was eventually worked out. Admiralty metal was cast in solid bars and rolled cold into sheets. Discs were cut from these sheets, which were pressed into a cup shape, as in the manufacture of cartridge cases. These cups were afterward drawn into tubes and the process produced a fine uniform tube free from gas holes. Another advantage is that the rolled sheet can easily be inspected on both sides before being drawn, so that a good surface both inside and out is assured.

With regard to the thickness of condenser tubes, it is sometimes considered that the thinnest tube will give the best heat transfer. This does not appear to be the case in commercial practice, as a test that was made with tubes 0.049 in. thick, and also 0.065 in. thick indicated that practically there was no difference in the heat transfer, which would justify reducing the thickness of the tube beyond a certain point. It is advisable to have sufficient thickness in the tube to resist the strains of condenser packing and ordinary strains of operation.

The marine practice for condenser packing is to use corset lace. This material produces the tightest joint, but is not suitable to acid circulating water where it usually deteriorates rapidly. Fiber packing is used to a large extent in fresh water. The Navy requires a tight condenser. A leakage of one-half of one per cent would be a handicap where the feedwater is distilled from sea water, and the impurities of salt water produce a severe foaming as well as a corrosive action. Metallic packing is comparatively a recent development and is gaining favor in some quarters. Present experience is not sufficiently extensive to justify definite authoritative conclusions regarding its merits.

Motor Records and Motor Maintenance

By J. D. Eberhardt

Recently, several very helpful articles dealing with the subject of motor-maintenance records have appeared in *Power*, and the following is offered as a further help to many in charge of electrical equipment, who desire a simple and readily workable system for following up and keeping the run of the condition of the motor in use. I am employed in a manufacturing plant where a number of motors are operated varying from 1/15 hp. to 30 hp. Most of them are small, and with the ever-increasing tendency toward individual drive, the units in use will undoubtedly continue to be of small capacity. At present some group drives are used, but the additional equipment is all individually driven, and much of it is direct-drive. In the near future it is hoped to eliminate the group drives entirely.

As this is a wood-working plant, there is a great deal of dust present, and many of the motors become extremely dirty in a short time. Alternating-current motors are used exclusively, and so far we have had very little trouble with any of them. Since a central air-compressor and air-pressure pipe system is not available, we have mounted a small two-cylinder air compressor with a geared motor onto a tank, and built a substantial truck for the whole outfit. The compressor is rated at 2½ cu.ft. of free air per minute at 150 lb. pressure, and the motor is ½-hp. single-phase. The necessary air-pressure gage, safety valve, air hose, nozzle, portable cord, etc., are provided, so that we have a complete portable compressor plant. This apparatus was constructed at an appreciable saving over the cost of a factory-built outfit. In addition it serves to pump up the dry-pipe valve system. With the tank pressure up to 125 lb. and the compressor running, we are able to clean closely grouped motors in quick succession.

For keeping the necessary useful records of the motor equipment, we have had printed two sets of cards 5 x 8-in.) as shown in Figs. 1 and 2. Two colors of stock are used, white for the three-phase machines and yellow for those using single-phase current. The cards are perhaps self-explanatory, but a few remarks may not be out of place.

As soon as a motor is received, the card, Fig. 1, is made out for it, filling in the nameplate data of the machine. As the dealer's name, price, etc., are kept in the office, we have no use for them in the work in question. The various items were chosen as well meeting the needs for the makes of motors we use. Any plant may easily make up a set of cards containing the necessary headings. If a motor is received and not immediately used, the card is marked "Stock" in pencil and

filed under that special heading. All active cards are filed alphabetically according to the name of the machine. If a motor is taken from service and placed in stock, the card for that motor is marked "Stock" and properly filed. When that motor is used again, a new card is made out, giving the name and location of the machine it is used on and the name and location of the machine on which it was formerly used. The first card is filed in the non-active file. It may be found to be desirable to number the cards, but up to now this has not been done.

The item "Rating" is of importance, for we have several continuously rated (50-deg.) motors and a number of 40-deg. rated. A 50-deg. machine may be useful in some cases, while one would hesitate to use them in a great many places. The item "Amperes" furnishes at a glance data for checking up the sizes of submains and branches. The item "Frequency" is not now of importance, as all our motors are 60-cycle machines; but when high-speed direct-driven machinery of certain types, utilizing a higher frequency to obtain higher speed, is installed, this heading will be of value. Under the heading "Drive" is simply noted whether the machine is direct-connected, belt, gear, or chain driven, etc. The item "Size of Fuses" enables one to provide renewals at a glance and also renders it easy to make an inspection and determine if replacements are being correctly made.

Under "Accessories" are noted the make, type, etc., of the compensator, if one is used, and the size of the

Machine	
Location	
Motor Mfr.	
Mfrs. No.	Model No.
Type	
Form	Frame No.
H. P.	Full Load R. P. M.
Volts	Amperes
Phase	Frequency
Rating	
Drive	
Size of Fuses	Our No.
Date Installed	
Accessories	
Repair Parts	
Front End B'r'g. L'n'g.	
Pulley End B'r'g. L'n'g.	
Repairs noted on other side.	

FIG. 1. CARD NO. 1, FOR MOTOR-OPERATION RECORD

disconnecting switch employed with the compensator, or with motors having only a switch the type, capacity, etc., of this switch. This enables one to determine, after some time, of course, any switches that are unsatisfactory. In the case of the generator the data concerning the field rheostat, etc., are filled in. For polyphase motors the only spare parts we have any occasion to keep in stock are bearing linings. By keeping a complete record of their catalog or part numbers, we may see how many motors use the same size of linings, thereby keeping maybe one set for several motors.

Machine				
Location				
Date	Cleaned	Oiled	Repaired	Remarks
Repairs noted on other side.				

FIG. 2. CARD NO. 2, FOR MOTOR-MAINTENANCE RECORD

For single-phase motors data concerning the brushes, commutator, etc., are of value. We also make a note on the card of any special features of construction, as ball bearings, fully inclosed type of machine, vertical machine, etc.

KEEPING RECORD OF MOTOR MAINTENANCE

For each machine in use the card, Fig. 2, is also filled out. These cards are used by the electrician who inspects and cleans the motors. We have not found it necessary to make a daily inspection of each machine. Some machines need cleaning at least once a week, while others require very little attention. Experience and observation enable one to divide the motors into groups, as, for example, those for which weekly attention is desirable, those that should be cleaned every two weeks, and those that need cleaning only once a month. When a motor has been cleaned and oiled, the proper card is dated and initialed by the man who did the job, and the card is filed at the back of the other cards of that group. In this way the machines are cleaned in rotation, and if anything delays the operation, each machine awaits its turn and none is neglected. The extent of any repairs made are noted on the back of the card, Fig. 2, and these are posted to the back of card No. 1, Fig. 1; therefore on the latter is a complete record of the motor.

The system outlined seems to me to be amply comprehensive for the needs of a small plant, and even for many large ones, and is not complicated or hard to follow up. A system that is simple and at the same time gives the necessary information is preferable to an elaborate, complicated accumulation of data that is not kept up to date and that is more or less unwieldly. Of course, to be of any service any system, even the simplest, must be kept up to date and in working order. If this is not done the system soon will fall into disuse which may lead to neglect of the equipment.

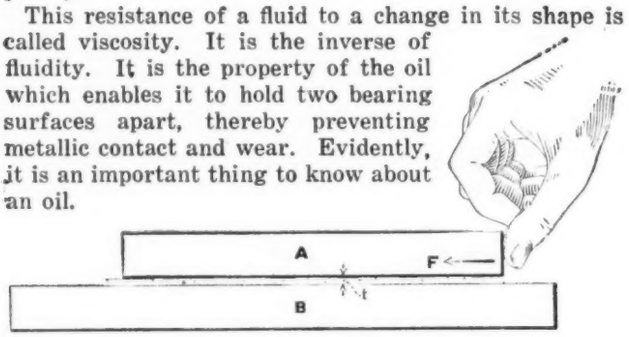
Lubrication—Absolute Viscosity of Oil

By W. F. OSBORNE*

EVERYONE knows that some oils will flow out of a can more quickly than others, and that when rubbed between two fingers there is a difference in the feel—one oil will rub out more quickly than another. This difference in the action of lubricants is controlled by a basic physical property called viscosity.

Force is always required to change the shape of any body, on account of the resistance of its molecules to a change in position. In the case of the oil flowing out of the can, the force is that of gravity; when rubbing the oil between the fingers, the force is the pressure applied by the fingers. Oils that have the greatest internal resistance are moved by gravity the most slowly; in other words, they flow out of the can less quickly.

This resistance of a fluid to a change in its shape is called viscosity. It is the inverse of fluidity. It is the property of the oil which enables it to hold two bearing surfaces apart, thereby preventing metallic contact and wear. Evidently, it is an important thing to know about an oil.



FRICTIONAL RESISTANCE

There are, in common use, a number of units of viscosity, which should be thoroughly understood, the principal terms by which they are known being absolute viscosity, fluidity, specific viscosity, kinematic viscosity, Saybolt viscosity, Redwood viscosity, furol viscosity, Engler viscosity, and other units.

In the sketch a plate A is supported parallel to the plate B by the oil film of t thickness. In order to move the upper plate, a certain force F will be required to overcome the resistance of the oil film. The amount of this force F will be determined by the rate at which the plate is moved and the shearing resistance of the oil film. The faster it moves the greater will be the force required. If the velocity is kept constant and the thickness reduced, it will require more force to maintain the same velocity on account of the increased rate of shear of the thinner film. Obviously, also, the total force required varies directly with the area of the upper plate. Reducing all these facts to the form of a formula, we find that

$$Force = \frac{shearing\ resistance \times area \times velocity}{film\ thickness}$$

Since the shearing resistance is known as the *viscosity*, our formula becomes

$$Force = \frac{viscosity \times area \times velocity}{film\ thickness}$$

Under the conditions of a plate having a surface area of one square centimeter and a film thickness of one centimeter, when a force of one dyne is required to maintain a velocity of one centimeter per second, the fluid is said to have a viscosity of one *poise*. This unit, the poise, is the unit of absolute viscosity.

The force required to overcome the frictional resistance between any two moving surfaces separated by a film of lubricant may be calculated from the general formula,

$$F = \frac{\mu a v}{t}$$

When metric absolute units of measurement are used, F will be the force in dynes, μ the absolute viscosity in poises, a the area in square centimeters, v the relative velocity in centimeters per second, and t the distance between the two surfaces in centimeters. When the English units of pounds force, square inches area, feet per second velocity and inches thickness are used, the viscosity of couurse being measured in poises, as there is no English unit of viscosity, the formula becomes

$$F = \frac{\mu\ a\ v}{5737\ t}.$$

Fluidity is the inverse of absolute viscosity. An oil of an absolute viscosity of 0.25 poise will have a fluidity of 4. Oils of low viscosities have high fluidities, and very viscous oils have low fluidities.

The poise is a comparatively large unit, and as many oils at their working temperatures have a viscosity of less than one poise, another unit, the centipoise, has been brought into common use. The centipoise is one-hundredth of the poise. An oil of an absolute viscosity of 0.25 poise has an absolute viscosity of 25 centipoises. Both terms are frequently used, although the latter is particularly advantageous as a unit of comparison, since the absolute viscosity of water at 20 deg. C. is almost exactly one centipoise, being 0.01005 poises.

Specific viscosity is the absolute viscosity of a fluid compared with the absolute viscosity of water at the same temperature. However, as the viscosity of water also changes with the temperature, common practice is to refer to the viscosity of water at 20 deg. C., at which temperature the absolute viscosity is 1.005 centipoises. On this account specific viscosity is a very convenient unit to use in visualizing the absolute viscosity of an oil, because everyone has a fairly good idea of the fluidity of water at 20 deg. C. (68 deg. F.). For instance, if we say the specific viscosity of an oil is 25, we know that it is twenty-five times as viscous as water at 20 deg. C., and will have twenty-five times the frictional resistance that the water has at that temperature.

Absolute viscosities are difficult to measure directly, except with the torsion viscosimeter, and on this account various instruments have been devised to measure units that have a relation to the absolute viscosity. These units are suitable for comparison within certain narrow limits and, if properly corrected for their variations, can be used to calculate the absolute viscosity of an oil. The principal trouble with the familiar viscosity units is that there is no constant multiplier or correction factor, nor do any of the various units have any direct relation between each other. Carefully worked out curves of calibration and conversion are usually necessary in order to obtain these relations.

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Water Power Resources of the United States—Developed and Undeveloped

RESULTS of an investigation of developed water power in the United States made by the Geological Survey in 1921 have just been made public and are given in full at the right-hand side of the accompanying table. Previously gathered figures on the undeveloped water-power resources of the nation are given at the left of the table for comparison.

The total water power developed in the United States as shown at the bottom of the table, is now 7,852,948 hp., which indicates an increase of 2,496,268 hp. since 1908. The figures for 1921 represent the capacity of the water-wheels installed in plants of 100 hp. or more. There are 3,116 such plants; 79 per cent of their total capacity is in public-utility plants and 21 per cent in manufacturing plants. The census of 1908 covered all sizes of plants, of which there were over ten times as many as

WATER POWER RESOURCES OF THE UNITED STATES

Division and State	*Undeveloped* Minimum Horse-Power	Per Cent	*Undeveloped* Maximum Horse-Power	Per Cent	*Developed* Total Number of Plants	Total Capacity in Horsepower	Public Utility and Municipal Number of Plants	Public Utility and Municipal Capacity in Horsepower	Manufacturing and Miscellaneous Number of Plants	Manufacturing and Miscellaneous Capacity in Horsepower
New England:										
Maine	443,000	1.59	809,000	1.50	256	449,614	71	156,549	185	293,065
New Hampshire	135,000	0.48	246,000	0.46	242	229,305	59	112,865	183	116,440
Vermont	94,000	0.33	172,000	0.32	206	129,566	59	72,651	147	56,915
Massachusetts	118,000	0.43	228,000	0.42	346	338,057	32	157,605	314	180,452
Rhode Island	6,000	0.02	13,000	0.02	60	30,136	5	3,510	55	26,626
Connecticut	72,000	0.26	137,000	0.26	124	133,829	20	79,950	104	53,879
Total	868,000	3.11	1,605,000	2.98	1,234	1,310,507	246	583,130	988	727,377
Middle Atlantic:										
New York	1,037,000	3.71	1,698,000	3.15	473	1,291,857	164	993,601	309	298,256
New Jersey	44,000	0.16	106,000	0.20	30	17,051	10	8,883	20	8,168
Pennsylvania	276,000	0.99	684,000	1.27	48	169,996	41	165,055	7	4,941
Total	1,357,000	4.86	2,488,000	4.62	551	1,478,904	215	1,617,539	336	311,365
East North Central:										
Ohio	59,000	0.21	178,000	0.33	25	28,663	17	24,236	8	4,427
Indiana	43,000	0.16	118,000	0.22	26	27,122	13	21,236	13	5,886
Illinois	192,000	0.69	345,000	0.64	41	85,002	15	73,591	26	11,411
Michigan	180,000	0.64	293,000	0.55	97	267,139	81	228,353	16	38,786
Wisconsin	358,000	1.28	670,000	1.24	134	330,737	66	195,473	68	135,264
Total	832,000	2.98	1,604,000	2.98	323	738,663	192	542,889	131	195,774
West North Central:										
Minnesota	232,000	0.83	494,000	0.92	56	205,180	35	145,247	21	59,933
Iowa	160,000	0.57	382,000	0.71	48	173,437	32	169,614	16	3,823
Missouri	72,000	0.26	163,000	0.30	7	17,970	5	17,670	2	300
North Dakota	88,000	0.31	207,000	0.38	1	245	0	0	1	245
South Dakota	43,000	0.16	75,000	0.14	8	18,227	5	6,050	3	12,177
Nebraska	196,000	0.70	366,000	0.68	39	14,726	25	12,036	14	2,690
Kansas	111,000	0.40	269,000	0.50	20	14,611	10	10,008	10	4,603
Total	902,000	3.23	1,956,000	3.63	179	444,396	112	360,625	67	83,771
South Atlantic:										
Delaware	5,000	0.02	11,000	0.02	9	3,133	0	0	9	3,133
Maryland	48,000	0.17	133,000	0.24	19	7,230	6	2,120	13	5,110
Dist. of Columbia					4	666	0	0	4	666
Virginia	492,000	1.76	870,000	1.61	71	103,693	35	76,551	36	27,142
West Virginia	381,000	1.36	1,051,000	1.95	11	14,675	6	8,410	5	6,265
North Carolina	578,000	2.07	875,000	1.62	70	255,843	30	126,070	40	129,773
South Carolina	460,000	1.64	677,000	1.25	21	330,012	16	321,250	5	8,762
Georgia	374,000	1.34	627,000	1.16	52	281,111	32	262,495	20	18,616
Florida	8,000	0.03	13,000	0.02	3	6,536	2	2,736	1	3,800
Total	2,346,000	8.39	4,257,000	7.90	260	1,002,899	127	799,632	133	203,267
East South Central:										
Kentucky	83,000	0.30	197,000	0.37	5	855	1	115	4	740
Tennessee	463,000	1.66	761,000	1.41	22	126,891	15	125,865	7	1,026
Alabama	509,000	1.82	943,000	1.74	16	117,788	9	102,400	7	15,388
Mississippi	32,000	0.11	63,000	0.12	0	0	0	0	0	0
Total	1,087,000	3.89	1,964,000	3.64	43	245,534	25	228,380	18	17,154
West South Central:										
Arkansas	22,000	0.08	61,000	0.11	2	1,189	1	720	1	469
Louisiana	1,000	0.00	2,000	0.00	0	0	0	0	0	0
Oklahoma	75,000	0.27	208,000	0.39	4	1,718	4	1,718	0	0
Texas	255,000	0.91	551,000	1.02	20	13,367	7	10,077	13	3,290
Total	353,000	1.26	822,000	1.52	26	16,274	12	12,515	14	3,759
Mountain:										
Montana	2,749,000	9.84	4,331,000	8.03	28	344,420	26	342,480	2	1,940
Idaho	2,362,000	8.45	5,067,000	9.40	45	224,368	41	222,471	4	1,897
Wyoming	773,000	2.76	1,305,000	2.42	9	7,560	9	7,560	0	0
Colorado	842,000	3.01	1,697,000	3.15	57	91,648	28	79,708	29	11,940
New Mexico	160,000	0.57	439,000	0.81	3	799	3	799	0	0
Arizona	893,000	3.20	1,698,000	3.15	8	38,760	8	38,760	0	0
Utah	743,000	2.66	1,318,000	2.45	64	106,096	51	101,844	13	4,252
Nevada	172,000	0.62	276,000	0.51	9	13,450	7	12,850	2	600
Total	8,694,000	31.11	16,131,000	29.92	223	827,101	173	806,472	50	20,629
Pacific:										
Washington	4,932,000	17.65	8,647,000	16.04	69	454,356	62	443,139	7	11,217
Oregon	3,148,000	11.27	6,613,000	12.27	74	185,215	52	125,970	22	59,245
California	3,424,000	12.25	7,818,000	14.50	134	1,149,099	106	1,129,954	28	19,145
Total	11,504,000	41.17	23,078,000	42.81	277	1,788,670	220	1,699,063	57	89,607
United States	27,943,000	100.00	53,905,000	100.00	3,116	7,852,948	1,022	6,200,245	1,794	1,652,703

those of 100 hp. and over, as covered in the present report.

Undeveloped, or potential, water-power resources are shown to be a minimum of 27,943,000 hp. and a maximum of 53,905,000 hp. The minimum figures are based on the average flow of the two seven-day periods of lowest flow in each year of record for each stream being considered, and although they do not give the absolute minimum flow, for all practical purposes they may be taken to represent continuous power. The maximum figures are based on the flow available for 50 per cent of the time. Both minimum and maximum estimates are considered to be conservative and were made without consideration of the use of water storage, which is now so generally employed.

In comparing quantities of developed and undeveloped water power, it must be kept in mind that the general practice is to install waterwheels with a capacity far greater than the minimum power available from the stream. This is especially evident in the New England and Middle Atlantic districts, where the developed water power is actually greater than the minimum available for each district. If all the water power in the United States were similarly developed, the installed capacity would probably be three or four times the minimum estimate of 27,943,000 horsepower.

New York State still leads in the amount of developed water power, with 1,291,857 hp. California is a close second, with 1,149,099 hp., but is far beyond even New York in public-utility power. Next in order come Washington, 454,356 hp.; Maine, 449,614 hp.; and Montana, 344,420 horsepower.

Survey Reports Marked Gain in Central-Station Efficiency

The United States Geological Survey's latest report on the output of electricity and production of fuels in central-station power plants shows a definite and encouraging increase in efficiency for 1921 over previous years. The report is complete up to the end of 1921 and summarizes the data for that year for comparison with 1920 and 1919. In explaining the figures on the

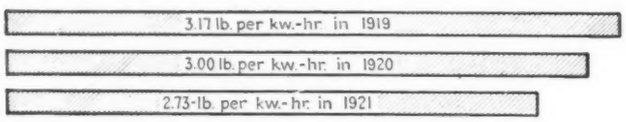


FIG. 1. CENTRAL STATIONS ARE LEARNING COMBUSTION EFFICIENCY

The Survey's figures show that the amount of coal burned to turn out a kilowatt-hour is being decreased.

consumption of various fuels, the report brings out the increase in efficiency in this way:

If the oil and gas are converted to equivalent coal and the kilowatt-hours produced by the burning of wood subtracted from the kilowatt-hours produced by fuel power, the rate of consumption of equivalent coal per kilowatt-hour in public-utility plants is found to be as follows: 1919, 3.17 lb.; 1920, 3.00 lb.; and 1921, 2.73 lb. This indicates a marked increase in efficiency in the consumption of fuel.

Fig. 1 puts these figures in concrete form so that their importance may better be realized by visualizing the increase in efficiency.

The table gives the totals, for three years, of electrical production from water power and from fuel power and of the consumption of coal, fuel oil and gas. Note that although the output of electricity has decreased 7 per cent from 1920, in that year it was 13 per cent over the previous year. Note also that the proportion of water power to fuel power has remained practically constant.

The curves shown in Fig. 2 are not especially interesting for any changes or tendencies that they show, but they do make plain the constant nature of the demand for power from central stations. This constancy is due, of course, to the fact that a large part of the demand is for the personal needs of individuals, and so is not

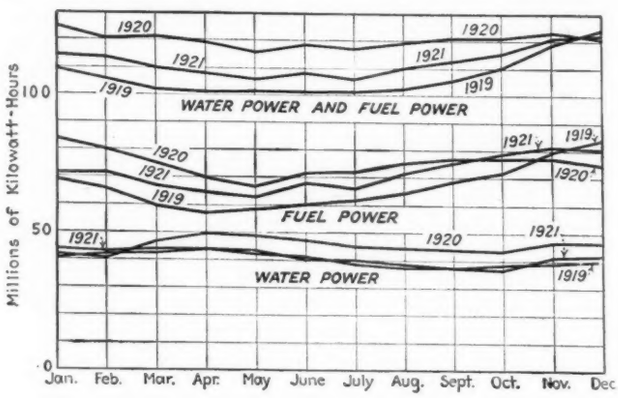


FIG. 2. THE CENTRAL STATION LOAD IS FAIRLY CONSTANT

These curves represent the average daily production of electricity for each month of the last three years and show that the variation has not been great.

greatly affected by business conditions. Industrial plants have quite a different problem.

A list of the production of electricity in each state in 1921, which is omitted here because of its length, shows California to be far in the lead as regards water power, with New York second. The ratio in some months was more than two to one. The other states were far behind these two. As for fuel power, however,

PRODUCTION OF ELECTRICITY AND CONSUMPTION OF FUELS FOR 1919, 1920 AND 1921

PRODUCTION OF ELECTRICITY

Year	Water Power, Kw.-hr.	Per Cent of Total	Fuel Power Kw.-hr.	Per Cent of Total	Total Kw.-hr.	Change From Previous Year Per Cent
1919	14,606,000,000	37.5	24,315,000,000	62.5	38,921,000,000	
1920	16,545,000,000	37.6	27,459,000,000	62.4	44,004,000,000	+13.1
1921	14,926,000,000	36.5	26,001,000,000	63.5	40,927,000,000	— 7.0

CONSUMPTION OF FUELS

Year	Coa Short Tons	Change From Previous Year Per Cent	Fuel Oil Barrels	Change From Previous Year Per Cent	Gas M. Cu.Ft.	Change From Previous Year Per Cent
1919	35,100,000	.....	11,050,000	.....	21,406,000	.....
1920	37,244,000	+ 6.1	13,123,000	+18.2	24,702,000	+ 15.49
1921	31,565,000	—15.2	12,016,000	— 8.4	23,746,000	3.

New York came first, Pennsylvania second, Illinois third and Ohio fourth, with California falling into the place of an "also ran."

It should be remembered that the figures given here are based on returns received by the Geological Survey from about 3,200 power plants producing 10,000 kw.-hr. or more per month, engaged in public service, including central stations, electric railways and certain other plants that contribute to the public supply. The capacity of plants submitting reports of their operations is about 90 per cent of the capacity of all plants listed. The output of plants that did not report has been estimated.

EDITORIALS

Relief at Last for Patent Office

PRESIDENT HARDING has signed the bill recently passed by the Senate increasing the force and raising the salaries of the Patent Office technical staff. Thus, much belated, but very welcome, relief is afforded this Government bureau, which is so vital to all technical and engineering development. It is to be hoped that applicants will now get from the Patent Office that service which it has been wholly unable to render in the past years because of Congress' penny-pinching policy in making appropriations.

Many other technical workers in government departments deserve quite as much in the way of attention and relief as did the Patent Office. It is fortunate, however, that the delay which would have been incident to a general reorganization and reclassification measure has not been allowed to interfere with immediate action for the Patent Office staff. The need there was no greater perhaps, but it certainly was more pressing.

Mexico Supplies Our Fuel Oil and More

OFFICIAL figures from the Treasury Department of Mexico have just been announced by the American Petroleum Institute as to the production in and export from Mexico of petroleum during the calendar year, 1921. These figures show that 172,000,000 barrels out of the 195,000,000 barrels of petroleum produced were exported from that country. And the recent figures from the United States Geological Survey show that the United States undoubtedly was the largest single consumer of these exports, as this country imported 125,000,000 barrels of crude oil during the same period, most of it from Mexico.

There is much loose talk regarding shortages of petroleum and declining rates of production in the United States, with corresponding alarmist effort by those who prophesy that the United States has now barely twelve years' supply of crude petroleum underground, and other similar alarming predictions. All such extreme statements can be generously discounted, but there is no question that today the United States *is* dependent for continuous operation on the present scale upon the *regular* supply of considerable quantities of Mexican petroleum.

During the last year the domestic production of petroleum is reported as 470,000,000 barrels and the estimated domestic consumption as 525,000,000 barrels. Thus it is clear that about 55,000,000 barrels of our consumption came from the imports, mainly those from Mexico. It would be possible, of course, to take the domestic production of the United States and by adequate installation of Burton-process "cracking" stills make sufficient quantities of gasoline and kerosene to meet the domestic demand (and perhaps even to meet the foreign demand for exports) of these two important refinery products. However, any such procedure would be possible only at the expense of fuel oil. It would practically eliminate from the domestic market gas oil and fuel oil, upon which so many power-plant operators and gas works depend for fuel and gas making. Moreover, it would severely limit the production of lubricants and doubtless result in the production of a very inferior quality of lubricant for many purposes.

For the present and so long as our imports are adequate, we can depend on Mexico and other similar sources for sufficient crude to permit the supply of this fuel oil, but that condition cannot prevail indefinitely.

Not Enough Ash in the Coal

MECHANICAL friction is ordinarily thought of as something that is always hindering the attempts of men to make the world run smoothly with their mechanical devices. Yet if friction could be abolished, we would be far worse off than we are now. In fact, it is doubtful if we could get along at all without this "enemy." Without friction, walking would be impossible, brakes would not hold and everything would go skidding around in its own sweet way.

A similar, though less extreme case, is that of ash as found in coal. The fireman looks upon ash as an unmitigated nuisance, as a useless material that must be handled twice, once hidden in the incoming coal and again as the chief constituent of the furnace refuse. Above all, he rightly blames it for the clinkers that take the joy out of his life when the coal has a high percentage of ash fusible at the temperature of the fuel bed.

But there is another side to this question. What would happen, particularly with hand-fired furnaces and overfeed stokers, if the coal contained no ash at all? The answer seems obvious. The grate bars, being brought into direct contact with white-hot coal, would be destroyed in a few hours in spite of the cooling effect of the incoming air.

Coals entirely free from ash do not occur, but there have been cases where the coal used was of such a "high" grade and contained so little ash that much trouble, in the form of burned-out grate bars, was experienced. An example of considerable interest is described by S. B. Flagg in this issue, in an article entitled "Low-Ash Coal Not Always Desirable." In this case the coal was distinctly "high grade," having a heat value of 14,585 B.t.u. per pound and containing only 4.30 per cent of ash. Yet the trouble experienced was as serious as any clinker trouble could be. The hollow grate bars of the stoker burned out repeatedly and at short intervals.

A scientifically conducted test showed conclusively that all the trouble was due to one cause—there was not enough ash in the coal! In fact, when a fair percentage of ashpit refuse was mixed with the fuel, the trouble stopped entirely. As this remedy was hardly practicable for regular operation, the coal was changed to one of higher ash content. Thereafter there was no more difficulty due to burned-out grate bars.

Two Muscle Shoals Offers Compared

THE Alabama Power Company's offer for Muscle Shoals has been placed before Congress by Secretary Weeks. It is distinguishable from that of Mr. Ford in that it is wholly a power proposition, a fact that simplifies its consideration, but at the same time leaves the matter of fertilizer production unsolved.

In its favor may be listed the provision for a fifty-year lease, which in certain respects is preferable to the one-hundred year tenure required by Mr. Ford. Its acceptance would probably obviate litigation and it would not require the Government to construct Dam No. 3. On the other hand, it would necessitate the Government turning over to the Alabama Power Company the partly completed Wilson Dam without reimbursement for the sixteen millions already expended. The Ford offer provides for amortizing this sum during the life of the lease. The latter proposition would require the Government to lend the money necessary for completing the hydro-electric works, for which it would receive interest at four per cent plus amortization payments. With the power company's offer this would be privately financed.

In both cases the Government would receive cash payment of five million dollars, with this difference: In accepting the Ford offer the Government would give up title to the nitrate plants, but would have the assurance of plant No. 2 being maintained in a state of military preparedness, in addition to the incentive of cheap fertilizer. If the Alabama Power Company's offer is accepted, the Government would retain the nitrate plants, minus the steam plants, to be held in a stand-by condition or to be disposed of as Congress may see fit. To hold them in a stand-by condition would probably cost the Government about $200,000 a year.

True, the Alabama Power Company proposes to furnish, without charge, to the Government or anyone the latter may designate, one hundred thousand horsepower from the hydro-electric plant for the production of fertilizers or munitions. This power, however, is limited to the second one hundred thousand horsepower at any time available from the normal flow of the river. Having in mind that the average maximum flow will provide only one hundred thousand horsepower throughout the twelve months, this part of the offer loses much of its attractiveness, for the power that would thus be supplied free would be available only at certain periods of the year. Therefore the Government, having turned over its steam plants to the company, would, if it operated the nitrate plants continuously, be compelled to purchase power during the remainder of the year. Moreover, Congress has gone on record as opposed to the Government going into the fertilizer business. The offer of the company to buy back this power, if not used by the Government, would offset absence of payments on the partially completed Wilson Dam.

Obviously, about the only alternative would be to lease the nitrate plants to some chemical company which would operate them on terms that would insure the necessary military preparedness. But with this arrangement the proposition of cheap fertilizer would be lacking.

The agricultural interests have very strong friends among the Congressional committees that are considering the two offers, and it would seem that any proposition would have to be otherwise very favorable if it ignored the question of fertilizer.

Are You Making Your Inspections Complete?

IN THE power plant, as most everywhere else, the things that do not make their faults manifest by immediate trouble are liable to be overlooked and neglected. On the other hand, equipment that gives serious trouble if not cared for is more likely to receive attention. If bearings are not lubricated, the machine soon refuses to function and the operator has a repair job on his hands. It does not require many such experiences to get the idea over that one way to avoid trouble is to keep the bearings lubricated. If the commutator and brushes on direct-current machines are neglected, sparking results, and for this reason operators may give careful attention to this part of the apparatus while neglecting other parts that may go long periods without causing difficulty. However, it is generally recognized that such maintenance methods lead to complications sooner or later.

A storage battery will operate for long periods with little attention and without giving trouble. It has no bearings to burn out or commutator or brushes to spark and flash and cause trouble if neglected. As a result of this it is probably, in general, one of the most neglected pieces of power equipment. If the cells are kept filled with electrolyte and charged occasionally, the battery may run for long periods without apparently requiring any further attention. During this period many things may be happening in the cells to shorten their life and cause the battery to fail at a critical time.

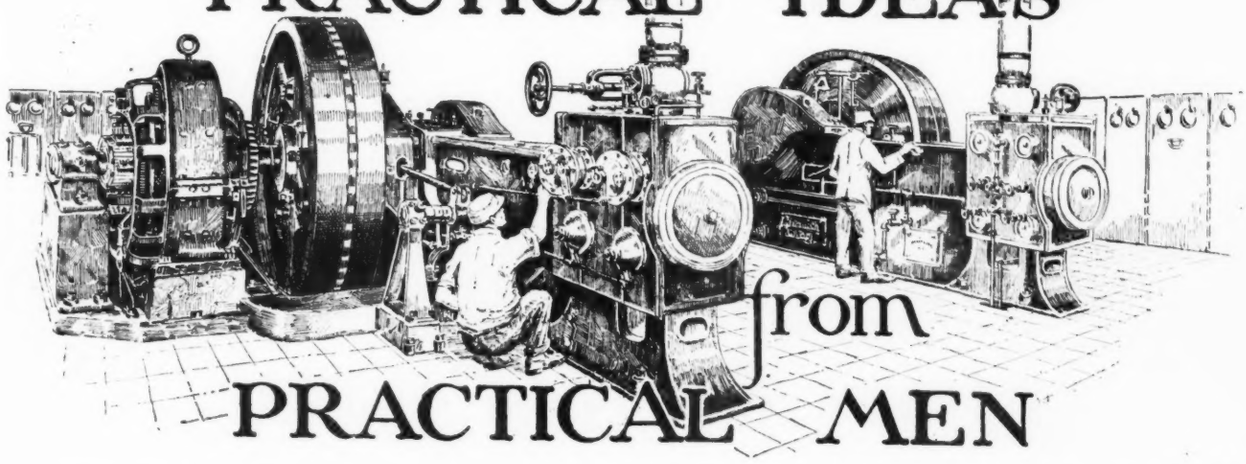
When a storage battery is used for control purposes and emergency service, it is particularly subjected to conditions that are gradually injurious. The circumstances under which it operates do not allow it to receive the benefit of the allowable range of charge and discharge. It must be kept nearly charged at all times. Such conditions are conducive not only to injury to the battery but also to neglect, and unless regular periods of inspection and maintenance are arranged for and rigidly lived up to, laxity in the care of the battery is likely to ensue.

Another feature in the care of storage batteries is the method of overhauling. If proper preparations are not made to do the work and it is not done in a systematic manner, more harm than good may result. In this issue the article, "Overhauling Storage Batteries," by Chester Schenck, gives methods of doing the work that are effective and complete in detail and that, if carefully followed, will not only result in obtaining the service which the battery was intended to give, but also will prevent its failure at some critical period.

The cost of protection for an electric system is small compared with the total cost of the installation. The difference in cost between a cheap and unreliable system of protection and the best is only a fraction of one per cent of that for the total installation. Since protection of electric circuits is relatively cheap, it is false economy to take chances of damage that may result in costly repairs and still more costly delays due to the equipment being out of service, all for the sake of saving a few dollars on protective apparatus.

That it is possible to "fool some of the people all the time" seems to be borne out by the apparently thriving business in coal-saving nostrums in spite of the numerous exposures that have been made.

PRACTICAL IDEAS from PRACTICAL MEN



Why Do the Piston Rings Break?

We are operating a 13 x 18-in. simple side-crank engine, non-condensing, exhausting against about five pounds back pressure and driving a circulating-water pump for a condenser. The steam pressure is 225 lb. gage, with a total temperature of 540 deg. F. The speed of the engine is 240 revolutions per minute.

We have considerable trouble with broken piston rings and with wearing of the cylinder walls, especially on the bottom of the cylinder. The cylinder has been rebored and new piston rings made according to standard practice, but the rings will last only from four to six months. We are using a high grade of cylinder oil and have changed the kind several times, but notice no difference in the results.

Any suggestions from readers of *Power* as to what might be the cause of our trouble and what can be done to prevent it will be welcome. O. HILLIARY.

Long Beach, Cal.

Cleaning Water-tube Boilers

In a discussion among a group of operating engineers, relative to the time and labor required for cleaning the different types of water-tube boilers the consensus of opinion seemed to favor the vertical in preference to the horizontal baffle. Experience has shown me, that with vertical baffles and cleaning doors in the side walls the soot can be much more quickly and thoroughly removed than in a boiler having horizontal baffles. Once the soot is blown from the tubes by steam or, preferably, by compressed air, it must fall on the grates or in the combustion chamber, where it can be easily shoveled out. On the other hand, when the tubes of a boiler having horizontal baffles are blown through the hollow staybolts with a steam lance, a large amount of soot falls on the lower baffle, and to remove it from there the tiles must be turned.

I recently had charge of a plant having three boilers with horizontal baffles, burning No. 2 buckwheat coal. Each boiler was taken out of service for cleaning every six weeks, and notwithstanding the daily use of a standard-type soot blower, soot would pile up on the lower baffle, often higher than the second row of tubes, necessitating turning the tiles. The weight of the soot, added to the tiles resting on the bottom row of tubes, would cause the tubes to sag, but not all the same, nor straight down, so that some of the tiles (which were a good fit originally) would cock up on one edge, allowing the hot gas to short-circuit through the joints of the tiles, to the next pass. These had to be fitted to the changed position of the tubes, and that took time.

City water was used for boiler feed, and for internal cleaning we gave each boiler a pailful of sal soda, dissolved in boiling water, once a week, and when the boiler was empty, once in six weeks, two gallons of kerosene oil was put in and the water pumped in slowly, so that the oil floating on the water could reach every part of the iron. In turbining the tubes (which we did annually), we never obtained as much as one-half peck of scale from either boiler. The mud drums were inside the steam drums, the feed water entering at the open front end, and the mud had to be removed through a 4 x 5-in. handhole at the rear, a rather awkward job. Another type of boiler, with the mud drum at the bottom of the rear leg, with generous-sized handholes, is much more convenient to get at.

In our case the results paid for the labor, for when these boilers were clean, their steaming qualities were unsurpassed. One word in passing, about soot blowers. I have found that the valves controlling the steam require frequent attention, as a small leak will form considerable condensate in a short time which soon finds its way to the nozzles inside the water legs, and before it is realized, there is a streak of red rust down over the tubes, and corrosion sets in if it is not checked.

A street-railway plant in New York City was burning 90 tons of soft coal a day, and up to the time I took charge the boiler tubes had been cleaned by hand with scraper and brush. In fact, the boiler turbine, as we know it today, was not in existence. I prevailed upon the management to have the boiler tubes bored out, and a contract was let for the job, at $1,500 for the eleven boilers. The work was done by means of a 10-hp. vertical steam engine, suspended from a wire cable stretched across the boiler room, by an eyebolt in the cylinder head, and attached to a trolley wheel. The steam pipe was made up of 4-ft. lengths of 1-in. pipe with elbows and nipples, so that the engine was able to follow up the flexible shaft which operated the cutter. I do not remember how much scale was taken out of those boilers, but it was a large quantity. Many of the tubes in the bottom rows were filled with scale, and the tubes burned away where they were laid in the brickwork at the rear of the furnace, so that only the

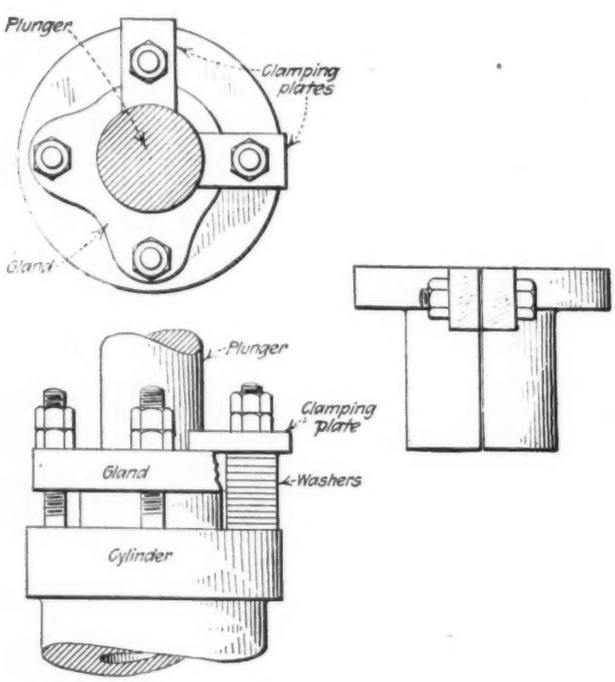
scale held against the boiler pressure (115 lb.). About 40 tubes had to be replaced. When the job was finished and a few changes made in the valve gear, our coal consumption was reduced from 90 to 55 tons a day. Quite a satisfactory piece of work. M. M. BROWN.

Camden, Me.

Repair of Elevator Packing Gland

While a high-pressure hydraulic elevator of the inverted vertical cylinder type was in operation recently, the plunger suddenly began leaking badly. After the car had been run to the bottom of the shaft and the water-supply valve was closed, an examination showed that two of the four lugs on the plunger packing gland were broken off. It was apparent that the gland had been pulled down on the broken side, while the nuts on the other side had been left slack, thus causing the inner end of the gland to pinch the plunger under a great stress.

As a temporary repair the engineer first removed the nuts on the broken side; also the detached lugs. He then made two clamping plates, by drilling the necessary holes in short pieces of 3 x 1-in. bar iron, and slipped them over the studs, having first dropped enough round washers over the studs to build up to a height



TEMPORARY REPAIR OF BROKEN GLAND AND CONSTRUCTION OF NEW GLAND

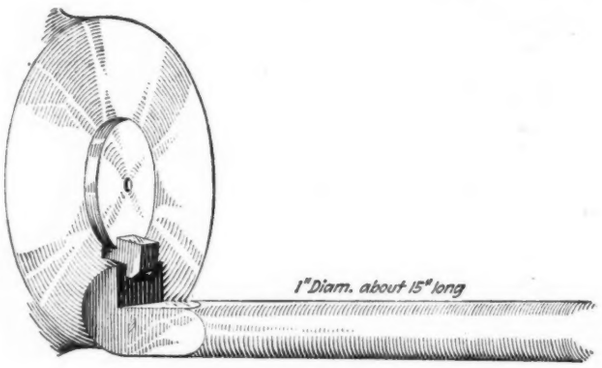
sufficient to insure the packing being tight when the nuts were pulled up snug against the clamping plates.

The job is shown at the left of the sketch. The edges of the clamping plates next the plunger were filed concave to conform to the curvature of the plunger. This repair held until a new gland could be obtained. To save the trouble and expense of removing the plunger from the cylinder, the new gland was made in two pieces, which were bolted together as shown at the right in the illustration. A. J. DIXON.

St. Louis, Mo.

One Way To Remove Small Key

A piece of steel bent at one end and ground down as shown by the sketch makes a convenient tool for extracting small keys. Usually, when a key is started



APPLICATION OF EXTRACTOR

it will come out easily, but should it require force all the way anything handy can be used under the extractor until the key is drawn. JOHN D. POTTER.

Linden, N. J.

Removing Burnt Spots From Generator Core

We had a 5,000-kva. and a 1,100-kva. machine burn out; large holes were burned in the laminations, some of the teeth were burned off, and the laminations at the bottom of the slots were badly welded together. The station electrician made a hurried repair, but it did not cut out the welded or burned spots, and after the machines were dried out, one burned out upon building up the voltage and the other broke down within two hours.

With the thought of making a temporary repair, I first tried a chisel on the burned iron and the chisel would not "stand up." An oxyacetylene welding and cutting apparatus was then secured, and we burned or cut off all the damaged teeth, burned out or annealed all the welded laminations and then with portable grinders ground off the annealed and burned laminations.

As there was not much room in which to work, we could not grind out all the places, so by using an air hammer and sharp chisel after driving some wedges into the ventilating ducts so that the iron would not bend, we were able to cut away the remainder of the burned iron. Seven teeth were cut off entirely from about two to five inches, and two teeth had the slot that supports the wooden wedges ground off for about twelve inches.

The coils were then inserted and were supported where the teeth were removed, by armature twine through the ventilating ducts, the twine being tied around wooden blocks outside the ducts.

This generator ran, carrying full load, for two months, after which it was shut down and new laminations were put in. The coils were found to be in excellent condition at the place where the iron was cut and ground off. There was no sign of a burn or of a break due to vibration.

The 1,100-kva. generator had its laminations treated the same way, but as the coils were not so stiff and the

teeth were cut out for a longer distance, I considered the danger due to bending and breaking of the insulation too great. The machine was wound single-star, and only three coils in two phases were injured, so I cut out only nine coils and connected up. We were not able to carry a full load in current on this machine, because we could not over-excite it enough, but it carried the load until it could be shut down for repairs.

Phœnix, Ariz. J. TALLA.

Operating a Motor with Ground in Armature

On an ungrounded circuit a single ground on a motor will not interfere with its operating. If the supply circuit is grounded, another ground on the motor will put the machine out of commission, because the two grounds form a bypath which cuts out part of the

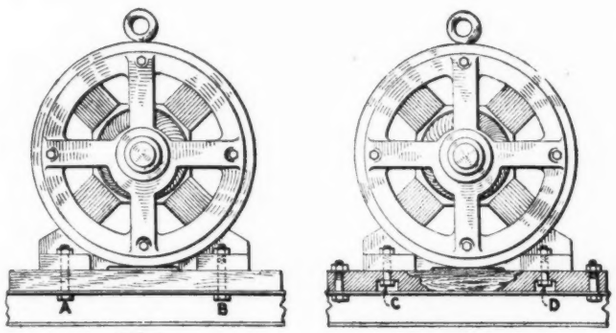


FIG. 1 FIG. 2

FIGS. 1 AND 2. SHOW HOW MOTOR WAS HELD DOWN BEFORE AND AFTER GROUND OCCURRED IN ARMATURE

motor circuit. Just what the effect may be depends on the location of the motor ground fault.

An elevator motor developed a grounded armature. It was very desirable to keep the motor in operation, if possible, until a spare armature could be obtained. The power system was grounded, and the frame of the motor was provided with a ground wire. As the motor apparently was mounted entirely on wood, it was thought that by disconnecting the ground from the motor frame, it might be possible to operate with the grounded armature. The ground wire was removed, but a test with a lamp circuit disclosed that the frame of the motor showed dead ground. Investigation revealed that although the motor frame rested entirely on wood, the holding bolts *A* and *B*, Fig. 1, passed through the web of an iron girder which itself was dead grounded. In order to overcome this difficulty, the bedplate bolts were taken out and the under ends of the bolt holes through the wooden cribbing were counterbored, as indicated at *C* and *D* in Fig. 2. This relieved the frame of ground and made practicable the operating of the grounded armature until the spare one was available. With the armature grounded and the frame insulated from the ground, the frame constituted a menace to anyone standing on a grounded part and touching the frame—and this is one of the conditions which justify the Underwriters' requirement that the motor frame be effectively grounded. In this particular instance danger signs were placed around the motor until after replacing the armature and the motor ground wire was restored.

Brooklyn, N. Y. E. C. PARHAM.

Engine Had a Heavy Pound

Recently, I took charge of a steam plant having a 125-hp. engine. Several engineers had been tried, but none of them had been able to locate the cause of a heavy pound.

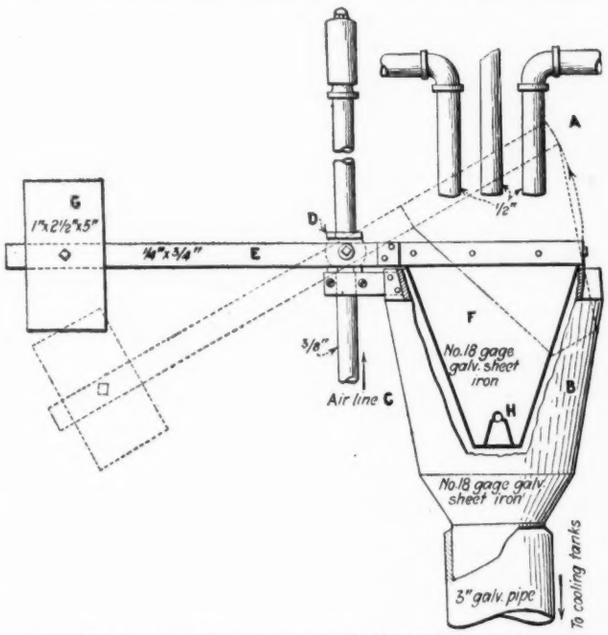
I made a general survey of the engine and then took indicator diagrams, but the valves were found to be properly adjusted. It was decided that the engine might be out of line. It was taken down and then lined up. In reassembling the main bearings, crank and crosshead brasses were properly adjusted and the piston examined to see that it was not loose on the rod; in fact, the engine was put in good shape. When it was started, the pound was still present.

I shut down and the engine stopped on the center. I took hold of the flywheel to turn it off and noticed a slight lost motion. It then struck me that the flywheel was loose on the engine shaft. An examination showed that the key had worked out slightly, which allowed the flywheel to be loose enough to cause the pound when it traveled over certain quarters. I put in a new key and drove it in snug, and there has been no trouble since.

South Boston, Mass. F. HOLT.

Water-Shortage Signal for Air-Compressor Cooling System

I have known of a number of cases where air-compressor cylinders have been scored and the valves warped from excessive heat, caused by the water circu-



WHISTLE ALARM FOR AIR-COMPRESSOR COOLING SYSTEM

lation being blocked or the water supply cut off at some point unknown to the operator. Some plants are equipped with water-cooling systems, and the water is used over and over again, being circulated by a pump. Others use city water direct and the waste water from the compressors runs into the sewer. With each method of water supply to the compressors, a cessation of water flow will cause trouble, and at times a complete shutdown of the plant, especially where the work done in the plant depends on its air supply.

I have forestalled this by a simple arrangement of a whistle signal. The outlets for the waste water are centralized, as shown at *A*, and discharge into a funnel *B*. A ¾-in. air line *C* is run from the air receiver and is secured to the funnel *B* as shown. On the outlet end of the pipe is a whistle. The valve *D* is fitted with a lever *E*, to which a ladle *F* is riveted on one end. On the opposite end of the lever a suitable sliding counterweight *G* is arranged. The whistle can be located where it will be most convenient for the operator to hear it when it whistles.

When operating the compressor, waste water comes from the centralized outlets *A* and runs into the ladle *F*. When the ladle is full of water, it swings downward and closes the whistle valve *D*. The ladle has two ½-in. holes drilled in the bottom at *H;* it holds approximately two quarts of water and will drain in less than one minute. Should the water stop flowing from the outlets *A*, the ladle *F* will drain and, becoming lighter than the counterweight, *G*, the latter will move to the position shown by the dotted lines and open the whistle valve *D*, causing the whistle to blow until water again flows from the outlets *A* or the machine is shut down.

In one installation I used an electric contact and three red lights instead of a whistle. One lamp was placed in the master mechanic's office, one in the general foreman's office and one in the engineer's quarters. The system was silent but effective. P. C. SAUERBREY.

Detroit, Mich.

Making Your Own Repair Parts

It is usually a mistake for any man, even if he is an expert mechanic, to attempt to make his own repair parts, excepting in an emergency, and then the repair part should be used only temporarily.

Take an actual example: A spindle in a control valve leaked. In trying to repair it, the engineer broke the spindle. It looked like a simple lathe job and so he decided to do the work himself, and he made a new spindle out of an old piece of mild-steel rod that had been lying around the plant. It took him six hours to make the spindle. Figuring the value of his time at one dollar per hour, the job cost six dollars. While he was making the spindle, other work of more importance was neglected. There were miscellaneous fuel and lubricant losses due to neglect that amounted, possibly, to another six dollars.

After installing the new spindle the engineer found that his work was not accurate, that the spindle leaked worse than before, and that he should have made it out of bronze instead of mild steel. He decided to have a new one made and sent the old spindle to a machinist and asked for an estimate on a duplicate part like the old one was before it broke. The machinist quoted ten dollars.

After installing this second spindle, leakage still occurred. The machinist claimed that the original spindle sent him was badly worn in addition to being broken, and that he had been told to "make the new one exactly the same size as the old one," which he did. The cost of the repair now amounted to $22 and still the job was unsatisfactory.

The engineer then looked over his repair-parts catalog (the thing he should have done in the first place), and found that he could get a new spindle for 75 cents. He telegraphed for it and received it the next morning by special-delivery insured parcel post at a cost of $2.50, including the cost of telegraphing, postage, insurance, etc. The total cost therefore was $24.50, whereas it should have been only $2.50. When the new spindle was installed, the leaking stopped.

Machine parts may appear to be simple, but they are made with remarkable precision in quantity-production turret and grinding machines at a cost that is usually insignificant compared with that of hand labor. The machine work is so refined and specialized that exact duplication is possible only after making the most painstaking measurements. W. F. SCHAPHORST.

Newark, N. J.

System in Hiring Help

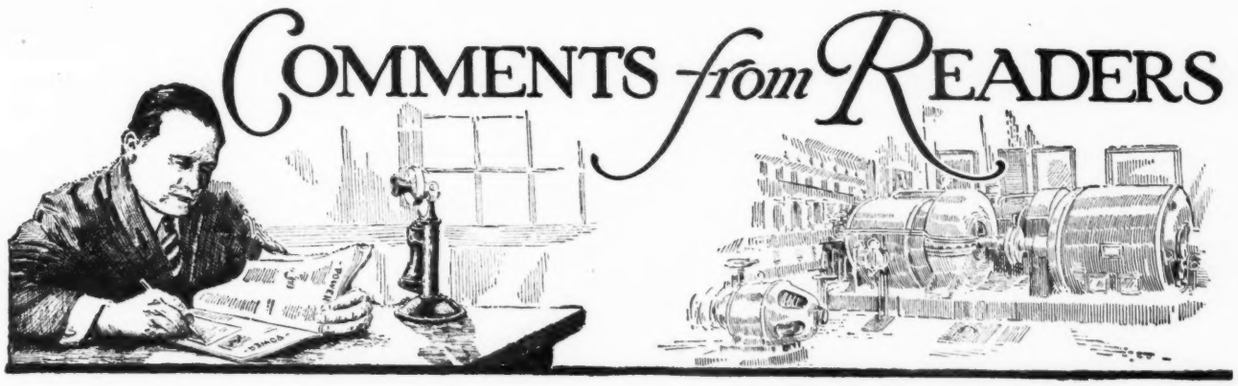
One of the items that tend to increase the efficiency and improve the operation of a plant is a system in hiring the help that is to operate that plant. The business of getting the right men for the job has always been something of a bugaboo to those that do the hiring, but I think I have a system that does away with the chance taken in engaging help.

When I hire a man, he gives me a signed statement relative to the devices in my plant with which he is familiar. I have a list of the equipment we have in each department. When a new man is taken on, he checks on this list the equipment with which he is familiar. I then take the checked list and have a general talk with him on the matters with which he claims acquaintance, and if he shows intelligence and familiarity with the devices, I engage him, all other factors being satisfactory. By this method I secure a signed list of the devices we have that the new man is capable of handling, and this enables me to know what I shall have to explain to him, and that in itself eliminates a lot of work.

In plain words this list of equipment forms what my man will have to handle to make good on the job. Of course I try to be fair and I do not expect a man to be able offhand to know all the details of our equipment. I figure that there is a lot of study needed, if one is going to handle the equipment properly, but I look for a man to be able to handle about 50 per cent of my list and handle it well. In my files I have an instruction sheet relative to every device that comes under my supervision, and these sheets are open to my men. I look upon it as a pleasure to explain to a man that wants to know. I base my examination wholly upon a man's personal showing. If, in my mind, the man is out for the job and seems anxious to do what is right, I am willing to help him get it, no matter what kind of examination he passes. One of my favorite questions, and an important question to my mind is the following: "Give offhand all the data that can be secured from a steam-flow meter chart." Out of twenty men, all familiar with flow meters and their operation, but one could give me the correct answer to this question.

Fall River, Mass. ARTHUR D. PALMER.

A striking illustration of what safety work may mean in dollars and cents, aside from its human significance, was reported by John Sherry in a recent issue of the *California Safety News*, published by the Industrial Accident Commission of California. It was stated that in a recent personal injury case, the fact that a warning sign was in place at the time of the accident reduced the award of the court by four or five thousand dollars. The sign cost about 35 cents.



Preheating Air to Boiler Furnaces

I read with interest the article by E. R. Welles and C. T. Mitchell which appeared in the Nov. 29, 1921, issue of *Power* under the title "Utilizing Flue Gases to Preheat Air to the Furnace," and perhaps you will not be averse to having the opinion of a specialist upon the subject.

The preheating of air is not only a possibility, but is currently realized in France, with excellent results. We have made a number of installations and send you herewith the result of tests on one of them. We are therefore in a position to judge the figures in the article referred to. We are, for instance, able to say that in existing apparatus the value of the coefficient K does not exceed 5. On the other hand, the resistance for the air or gas is in general considerably less than 1 in. of water, and the power absorbed much less than that which is assumed by Messrs Welles and Mitchell.

TEST OF BOILER WITH & WITHOUT AIR HEATER

Make of boiler	Belleville (equipped with superheater & air heater)	
Boiler heating surface, sq. ft.	825	
Superheating surface, sq. ft.	380	
Grate area, sq. ft.	38.5	
Number of test	1	2
Air heater used	Yes	No
Date of test	Jan. 21,'21	Jan. 22,'21
Duration of test	7 hr.-50 min.	8 hr.
Fuel:		
Calorific value of dry coal, B.t.u. per lb.	13,400	14,200
Moisture, in coal as fired, per cent	2.7	2.5
Volatile, in dry sample, per cent	10.95	14.1
Ash, in dry sample, per cent	10.5	8.25
Fixed carbon, in dry sample, per cent	78.55	77.65
Pressures, Temperatures, etc.:		
Feed water temperature, deg. F.	45.5	45.5
Boiler pressure, gage, lb. per sq. in.	67	67
Temperature of steam leaving superheater, deg. F.	428	406
Temperature of air at inlet to air heater, deg. F.	56	....
Temperature of air supplied to boiler, deg. F.	194	77
Temperature of flue gas at boiler uptake, deg. F.	....	554—590
Temperature of flue gas at air-heater inlet, deg. F.	572—608	.....
Temperature of flue gas at air-heater, outlet, deg. F.	428—472	.....
CO_2 in flue gas, per cent	10.0	7.87
O_2 in flue gas, per cent	8.0	9.37
Draft at inlet to heater fan, in.	0.28	.....
Pressure at discharge from heater fan, in.	1.18	.....
Draft on boiler grate, in.	0.05	0.03
Draft before air heater, in.	0.14	0.10
Draft after air heater, in.	0.40	0.44
Weights:		
Dry coal burned per hour, lb.	567	531
Dry coal burned per sq.ft. of grate, per hour, lb.	14.7	13.8
Feed water supplied per hour, lb.	4,300	3,736
Saturated steam per hour to feed pump, lb.	154	133
Superheated steam produced per hour, lb.	4,146	3,603
Water evaporated per hour per square foot, heating surface, lb.	5.21	4.53
Evaporation and Efficiency:		
Saturated steam supplied to feed pump per pound of dry coal burned, lb.	0.27	0.25
Superheated steam produced per pound dry coal, lb.	7.30	6.79
Boiler efficiency (allowing for feed pump)	66.8	58.1
Boiler efficiency (not allowing for feed pump)	69.2	60.2

The complication due to, and the cost of, air heaters are less than is generally believed. The French apparatus is sold at 120 francs per square meter (about 75c. per sq.ft.) with the fans. The volume is only 30 cubic decimeters per square meter (about one-tenth of a cubic foot per square foot) for apparatus constructed with parallel plates, which presents numerous advantages over that constructed with tubes.

It is easy to see from these practical figures that air heaters rapidly pay for themselves by the net economies realized by their use, and that their installation is very simple. They are generally placed after and in series with an economizer of reduced surface, giving a combination apparatus less costly than any other arrangement.

EMILE PRAT.

Etablissements
Emile Prat-Daniel, Paris.

How Do the Governors Operate?

I have been operating waterwheel governors since 1911 and they work just the opposite way to that stated in an article on page 766 of the Nov. 15, 1921, issue of *Power*. Whether the servomotor works inward or outward to open or close the gates, the pilot valve works the one way in either case. Quoting *Power*, Feb. 17, 1920, p. 260, it is stated that "As soon as a change in speed occurs, let's say that some load has gone off the unit and that the turbine is now running too fast, then the pilot-valve stem will move downward." This is the way I have understood them to work and the way the ones I have operated have worked, but opposite to the way in which it is stated they operate in the article first mentioned.

I would like to know more about them. Possibly some reader has information on the subject, and a short article would be of interest to those who, like myself, think they all work the same way.

Temiskaming, Que., Canada. W. H. SMITH.

Cause of Explosions in Open Feed-Water Heater

I read with interest R. Miller's letter in the Dec. 20, 1921, issue, on "Explosions in Open Feed-Water Heaters." The explanation given by John F. Hurst in the Jan. 31 issue is logical and may be the correct one for this instance. One point, however, seems to have been overlooked; namely, that the velocity of the reverse flow of returns and exhaust steam from the heater to the tank when the air valve on the latter is opened would be considerably greater than that due to the release of the pressure built up by the vacuum pump alone on a horizontal line. This is because the vertical leg of the 3-in. pipe is given as 40 ft. high, which, being 6 ft. above the amount necessary to balance the atmosphere, acts similarly to a barometric condenser in that the falling water tends to form a perfect vacuum in the heater.

Long before the 700-ft. pipe could empty, the air valve would be closed, but if the valve had failed while open serious results might have occurred.

This would indicate that returns should never be pumped into a cast-iron feed-water heater under a head greater than the rated working pressure of the outfit, as an accidental reversal might wreck the heater. Check valves will, of course, lessen the danger if they can always be depended upon to operate when needed.

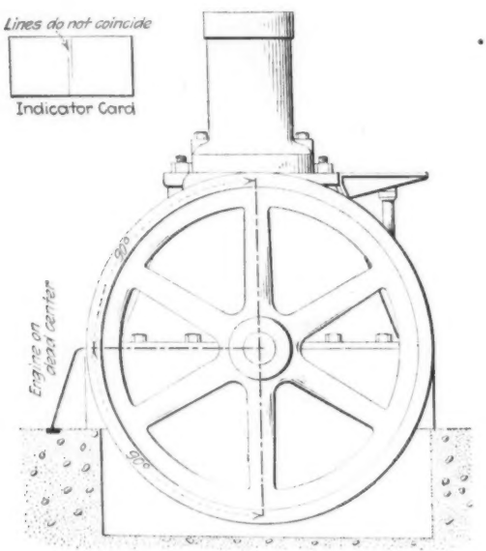
Camden, N. J. HERBERT R. BETTERTON.

Peculiar Diesel Indicator Diagram

The loop in the indicator diagram of P. K. Jones, *Power*, Jan. 10, 1922, is not real but apparent. I have had experience with just such loops and have always found that they were not due to any trouble in the cylinder, but to the manner in which the reducing motion is applied.

I notice that Mr. Jones mentioned that the reducing motion was obtained from the engine shaft. Doubtless the movement of the indicator drum was a few degrees behind the piston, and when expansion had begun within the cylinder, the indicator drum had not reached the limit of the stroke. This resulted in the indicator pencil dropping in accordance with the expansion in the cylinder, while the card was still moving in the same direction as for compression. This would make a loop, and it would not be fair to judge the performance of the engine from such a card.

I don't think the length of cord had so much to do with Mr. Jones' diagram as the angularity of the mechanism on the end of the engine shaft. I would suggest that he locate the error by the following method:

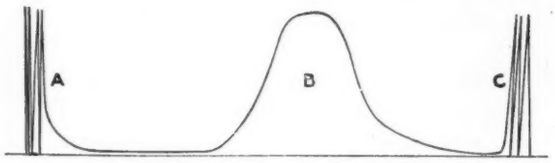


CHECKING INDICATOR REDUCING MOTION

With a card on the indicator drum, place the engine on dead center and put a mark on the flywheel, using a tram as shown. Then turn the engine forward approximately 90 deg., a measured distance on the flywheel, and scribe a vertical line on the card with the indicator pencil. The engine can then be turned backward an equal distance past dead center and a second line made on the card. The two lines thus drawn should coincide, since they represent the same amount of piston travel. If the lines do not coincide, the reducing mechanism should be corrected. It is necessary, however, to have the dead center point accurately determined.

Columbus, Ohio. RUSSEL K. ANNIS.

In regard to the peculiar Diesel indicator diagram discussed by P. K. Jones, the trouble is very simple to explain. The indicator reducing-motion was not properly timed with the engine, but lagged a considerable



PROPER WAY TO SECURE DIAGRAM

distance behind the piston, therefore the diagram is badly distorted.

When a reliable indicator gear is not available, it is better to take diagrams as the one illustrated. The first part *A* is obtained by pulling the string by hand very slowly. This shows the combustion pressure over a number of cycles. The part *B* is made with a fairly quick, steady pull of the string. While the horizontal scale is of course unknown, this gives a good indication of the valve action and process of combustion. The last part *C* gives the compression and should always be taken with the fuel cut off.

Stockton, Cal. CHARLES H. BUSHNELL.

The Diesel indicator diagram shown by Jones is an impossible or freak diagram in my opinion. Leakage of compression near the end of the stroke would give a loop similar to his, but it could not by any ordinary possibility be sharp at the point of highest pressure. If the fuel is heavy and slow-burning, with just a little gasoline to flash before the dead center is reached, it might come nearer to giving a sharp point at the top, provided there is also leakage.

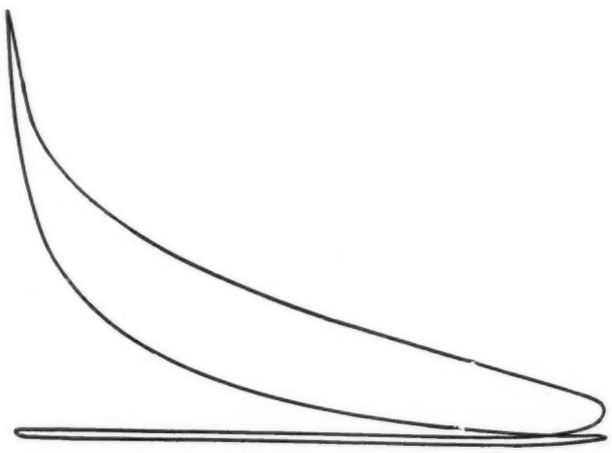


FIG. 1. DIAGRAM CORRECTED BY TIGHTENING DRUM SPRING

It looks to me very much as though the loop was caused by a lag in the indicator which caused the drum to fail to reverse its motion until after the piston had reversed and moved down a short distance. The two

reverse curves on his compression line indicate this. Possibly his reducing motion rigged from the end of the engine shaft caused this lag. It takes only a very slight lag of the drum to make quite a difference in the diagram, especially at the head end. Fig. 1 shows a cor-

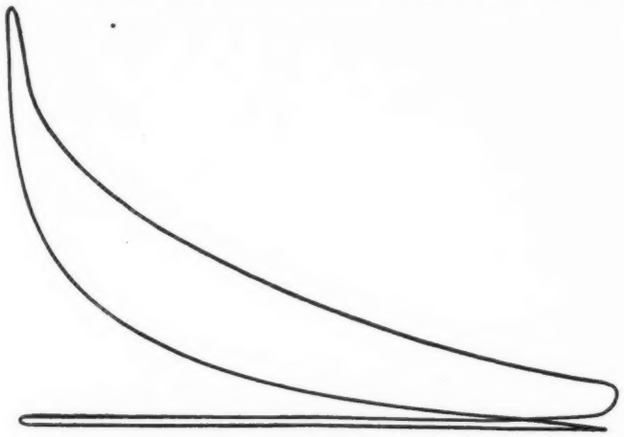


FIG. 2. CORRECTED DIAGRAM IF THE REDUCING MOTION WAS WRONG

rection of the diagram on the assumption that the point of highest pressure is exactly at the end of the stroke, and Fig. 2 shows what a correct diagram would look like if the end of the stroke corresponded with the point of the arrow, in his diagram.

However, I believe that Fig. 2 is the correct interpretation, as I do not see how anything could cause such a sharp point as his diagram shows except the reversal of the piston at the end of the compression stroke. As the crank end of Mr. Jones' diagram shows little if any lag, it is probable that the lag was caused by weakness of the spring that holds the cord taut. This spring is always weaker at the head end than at the crank end, and if the drum is not "wound up" a sufficient number of turns, the spring may have practically no tension at the head end, which, with the sag of his extra long cord and possibly too much elasticity in the cord, might give the inertia of the drum a chance to carry the card on a short distance after the other end of the cord (and the piston) had stopped at the end of the stroke.

I think if a more "orthodox" reducing motion is used a diagram similar to Fig. 2 will be secured.

New Orleans, La. GEORGE PEPIN.

Water Hammer in a Water-Tube Boiler

Mr. Gans' experience, as related on page 1024 of the Dec. 27, 1921, issue of *Power*, is not out of the ordinary, as water hammer is likely to occur when the feed pipe enters the top of the boiler and passes down through the steam space. Recently, one of the firemen reported a slight water hammer in one of our return-tubular boilers. A long-thread nipple was screwed through the shell and an extension was attached inside by means of a coupling, the lower end terminating in a feed pan.

When the boiler was cut out for washing, I tried the internal feed pipe with a hammer, and although it did not appear to be loose, it did not ring right. Being certain that the water hammer must be caused by the internal pipe, I tried a wrench on it, and it broke off, being cracked halfway around. As the lower end of this pipe was clear, the water hammer could not have been caused by the water spurting through the opening.

My theory regarding the cause of water hammer in such cases, is that steam enters through the opening and condensing, causes the hammer. I am not aware that water being injected into a volume of steam will cause water hammer, but steam injected into a volume of water will, and the colder the water the more violent it will be. R. MCLAREN.

Toronto, Ont., Canada.

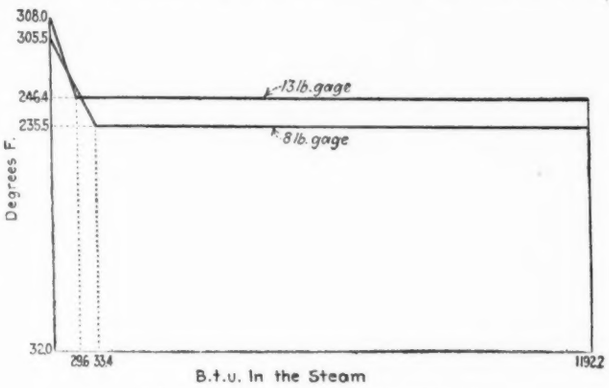
Reduction of Steam Consumption of Paper Machine Running Damp Paper

With regard to the relative quantity of steam required by dryers of a paper machine when running damper paper, as referred to on page 820 of the Nov. 22 issue, I do not think the best authorities would agree with the reasoning.

Retaining the values quoted we would obtain:

Gage Pressure	Absolute Pressure	Saturated Temperature	Temperature of Superheated Steam	B.t.u. in Superheat
125	140	....	....	...
13	28	246.4	308	29.6
8	23	235.5	305.5	33.4

As shown by the sketch, only a small fractional part of the heat of the steam will be transmitted at the maximum temperature of superheat and less than 3 per cent. of the total heat before the temperature of saturation is reached, so that for all practical purposes the whole transmission may be assumed to take place at saturation temperature. Furthermore, after passing over a very few of the drying cylinders the paper in contact with the dryers at least reaches a temperature of 212 deg., so that the effective differences of temperature for the transmission of heat are respectively 34.1 deg. for the 13-lb. gage dryers and



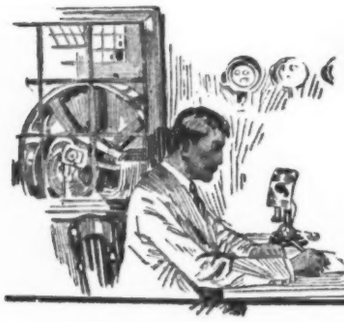
HEAT IN SUPERHEATED STEAM

23.3 deg. F. for the 8-lb. dryer, and the reduction in steam consumption will be more nearly in the proportion of $\frac{34.1 - 23.3}{34.1} \times 8{,}500$, or 2,690 lb. per hour, or nearer 31.6 per cent than 1 per cent.

In my experience the effect of even a pound difference in steam pressure in the dryers is quite noticeable when other conditions, such as air venting and removal of condensate, are maintained the same.

New Haven, Conn. H. D. FISHER.

Considerable progress has been made lately in the art of welding cast iron by the various electric-arc methods. While there is still room for improvement, present methods are such that good results are obtainable on the better grade of castings.



QUESTIONS AND ANSWERS

Draft Loss Through Boiler

In a water-tube boiler burning oil with back-shot burners, if the draft over the fire is shown by the gage to be 0.1 in., and the draft in the uptake is 0.4 in., does the difference, or 0.4 — 0.1 = 0.3 in., show the draft loss through the boiler? If not, how can the resistance be found? C. H. M.

If the draft over the fire is taken near the tubes at a point where the draft gage gives a constant reading, the difference between that indication and the draft in the uptake should be fairly representative of draft loss through the boiler. The more accurate method of obtaining the draft over the fire is to protect the draft-gage connection from currents and eddies of the gases.

Horsepower of Gasoline Engine

What horsepower may be expected from our four-cylinder four-stroke-cycle gasoline engine having cylinders 6 in. diameter by 6 in. stroke, 500 r.p.m.? H. N. G.

Engines of this type are usually rated at 1,000 ft. piston speed and the horsepower is calculated by the formula

$$Hp = \frac{D^2 \times No.\ cylinders}{2.5}$$

Since the engine has four 6-in. diameter cylinders, at 1,000 ft. piston speed, which with a 6-in. stroke is equivalent to 1,000 r.p.m., the horsepower $= \frac{36 \times 4}{2.5} = 57.6$, and at 500 r.p.m. the engine would be rated at $\frac{57.6 \times 500}{1{,}000} = 28.8$ horsepower.

Gathering Heating Returns of Different Pressures

We have a number of greenhouses supplied with steam from a central boiler plant, and as the pressure of steam for each house must be modified to suit the special requirements, the returns are of different pressures and cannot be gathered into the same closed receiver to be automatically returned by the pump to the boiler. How can this trouble be rectified? M. W.

Each return line should be drained to the pump and receiver through an independent discharge trap, and the receiver should be provided with a vent to relieve it of any pressure above that of the atmosphere. The best form of vent is a vapor pipe as large as the largest return pipe, independently connected with the top of the receiver, and thence carried to a point where the discharge of vapor is unobjectionable. If the vapor pipe is not properly pitched to be drained back to the receiver, it should be provided with open drips at any points where there may be traps in the line.

Pressure Obtainable in Water End of Pump

How much pressure could be obtained in the water end of a direct steam pump having a steam cylinder 12 in. in diameter and water end 10 in. in diameter, with steam pressure 125 lb. gage? W. F. P.

The piston of the 12-in. diameter steam cylinder would have an area of 12 × 12 × 0.7854 = 113.1 sq.in., and neglecting friction, the total pressure exerted by the steam on the steam piston and transmitted through the piston rod to the water piston would be 113.1 × 125 = 14,137.5 pounds.

As the area of the water cylinder is 10 × 10 × 0.7854 = 78.54 in., the pressure obtainable in the water end would be 14,137.5 ÷ 78.54 = 180 lb. per sq.in. Since the areas of circles are to each other as the squares of their diameters, the short solution of the problem would be $\frac{12^2}{10^2} \times 125 = 180$ lb. per square inch.

Efficiency of Internal-Combustion Engine at High Speed

Why is it that with the same engine the efficiency at 300 r.p.m. is greater than at 900 r.p.m.? If, as usually conceded, the frictional loss is constant regardless of the speed, it would seem that at the higher speeds and larger power output the efficiency should increase. J. H. R.

The discrepancy lies in the poorer scavenging of the cylinder at the high speeds, which lowers the thermal efficiency. In addition, at high speeds the combustion, which is by no means instantaneous at any speed, is carried on during the entire power stroke. This means that the heat, instead of being added at the highest temperature, is added at a falling temperature, giving a decreased efficiency. In addition, part of the fuel may be exhausted in an unburnt condition. On the other hand, with proper design, the high-speed machines may be more efficient than a slow-speed engine.

Economy of Wiredrawn Steam

If steam that is wiredrawn through the steam valve at cutoff superheats and if none of the heat in the steam is lost, why isn't such wiredrawing of advantage? I understand that superheated steam loses less of its heat to the cylinder walls? W. L. M.

The efficiency of an engine is the heat transformed into power divided by the heat supplied to the engine. The amount of heat which may be abstracted depends upon the temperature range between the steam at the beginning of expansion and at the end of the expansion. If the steam wiredraws, it does become superheated to a small extent, but its temperature is no greater than

the temperature of the steam before wiredrawing; in fact, it is lower. Consequently, since the temperature range between the two points in the expansion is less with wiredrawing, the efficiency will be less and the engine will require more steam per brake-horsepower.

Dimensions of Stated Proportion for Given Tank Capacity

The dimensions of a tank are 3 ft. × 5 ft. × 10 ft. What would be the dimensions of a tank of one-half the capacity with the dimensions of the sides in the same proportion? J. J. F.

Having the dimensions in the same proportion, the cubical contents of the tanks would be to each other as the cubes of corresponding measurements. The cube of 10 = 1,000; hence for the tank of one-half the capacity of the 3-ft. × 5-ft. × 10-ft. tank the dimension corresponding with 10 ft. would be $\sqrt[3]{\frac{1,000}{2}} = 7.937$ ft.; the dimension corresponding with 5 ft. would be $\frac{5}{10}$ of 7.937 = 3.9685 ft.; and the dimension corresponding with 3 ft. would be $\frac{3}{10}$ of 7.937 = 2.3811 ft.; that is, the dimensions of a tank one-half the capacity of one 3 ft. × 5 ft. × 10 ft. with dimensions in the same proportion, would be 7.937 ft. × 3.9685 ft. × 2.3811 ft.

Power Required to Drive a Single-Phase Generator

We have a load of 25 amperes on a single-phase 60-cycle 1,100-volt generator, and I would like to know the horsepower required to drive the machine under this load. The load is all lights, the current being stepped down through transformers from 1,100 to 110 volts. There is no wattmeter on the switchboard; only a voltmeter and ammeter are available. J. C. C.

To make this calculation accurately, there are two factors that should be known: namely, the power factor of the load and the efficiency of the generator. Lighting circuits supplied through small transformers have a power factor of about 0.90 under average conditions. Assuming the exciter to be driven from the alternator's shaft, the efficiency of the set may be taken at 0.80 (80 per cent). The power required to drive the machine is then found by the formula:

$$Hp. = \frac{E \times I \times P.F.}{764 \times Eff.}$$

where E equals the volts, I the current in amperes and $P.F.$ the power factor. Then, in this case,

$$Hp. = \frac{1,100 \times 25 \times 0.90}{746 \times 0.80} = 41.5$$

The foregoing calculation applies only to single-phase circuits supplying a lighting load through transformers.

Required Height of Stack

What is the formula and computation to determine the required height for a stack 80 in. in diameter to serve 1,000 hp.? W. O. A.

No stack formula can be constructed to fit all cases exactly, as too many varying factors enter each case. However, an empirical formula for height and diameter of stack that is largely used by engineers is that proposed by William Kent; namely,

$$\text{Hp.} = 3.33\ (A - 0.6\sqrt{A})\sqrt{H}$$

where Hp. is the number of horsepower served, based on a coal consumption of 5 lb. per rated horsepower per hour; A is the actual cross-sectional area of the flue in square feet, and H is the height of chimney above the grate in feet.

The quantity $(A - 0.6\sqrt{A})$ = the effective area of stack, based on the assumption that the retarding effect by friction of the ascending gases may be considered as equivalent to the diminution of the area of cross-section of the flue equal to a layer of gas 2 in. thick over the whole interior surface. Taking Hp. = 1,000 and $A = \left(\frac{80}{12}\right)^2 \times 0.7854 = 34.9$ square feet, then $A - 0.6\sqrt{A} = 34.9 - 0.6\sqrt{34.9} = 31.36$ square feet. Substituting, the formula becomes $1,000 = 3.33 \times 31.36 \times \sqrt{H}$, from which the value of H is found to be about 92 feet.

Measurement of Cylinder Clearance Volume

How is measurement made of the cylinder clearance volume of a steam or a gas engine? A. S. R.

The cylinder clearance volume in each end of the cylinder is most readily determined from the volume of water that can be contained by the clearance space when filled from the piston, when at the end of the stroke, back to the valve seats. An opening needs to be provided at the top of the cylinder at each end for introducing the measuring water; or the water may be introduced through the indicator connections, using a standpipe of sufficient height for completely flooding the clearance space, with suitable provision for escape of air from the cylinder during the process of filling.

Place the engine on dead center with the piston in the head end of the cylinder, and after removing the valves, cover each valve seat with a rubber gasket, held down tight by a block of wood wedged or bolted in place. Pack candlewicking around the piston to prevent leakage of water past the piston. For this purpose the cylinder head must be removed and again replaced.

Provide two vessels, each filled with clean water and take the weight of each. Then fill the clearance space of the head end from one vessel and make a note of the time required. As soon as the space is filled, the first vessel is to be set to one side and subsequently determining the weight of water thus used, and the clearance space is to be kept filled against leakage for five minutes by adding water from the second vessel. The vessels are again weighed to determine the weight of water used from each.

The average rate of leakage while filling the clearance space from the first vessel may be assumed to be one-half of the rate during the filling against leakage from the second vessel. If W = weight in pounds of water required to fill the clearance space from the first vessel; t minutes = the time required; and w = the weight of water in pounds necessary to keep the clearance space filled against leakage for one minute, then the leakage during the filling is approximately $(w \times t) \div 2$, and the clearance space will contain $W - [(w \times t) \div 2]$ lb. of water. This multiplied by 27.7 gives the space in cubic inches. The clearance volume of the crank end of the cylinder is determined in the same manner.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

A. I. E. E. Holds Midwinter Convention

FOR the three days Feb. 15 to 17 the American Institute of Electrical Engineers held its tenth midwinter convention in the Engineering Societies Building, New York City, having a total registration of 900. Five technical sessions were held at which twenty papers were presented and discussed. On Thursday evening the 15th, the Edison Medal was presented to Cummings C. Chesney, for early developments in alternating-current transmission. The presentation was followed by a lecture on Colloids by W. D. Bancroft. On Friday evening the convention closed with a dinner-dance at the Hotel Astor, at which 390 members and their guests were in attendance.

Of interest to operating men were two papers presented at the Wednesday evening session: "Questionnaire on Lightning Arresters," by F. L. Hunt, and "On Deviations from Standard Practice in Lightning Arresters," by E. E. F. Creighton. The questionnaire is from the 1921 annual report of the "Protective Devices Committee" and gives a summation of twenty replies received from operating companies to questions regarding what general types of lightning arresters they would recommend for feeders of 1,000-kw. and greater capacity, for voltages ranging from 10,000 to 150,000. The replies received indicate that the general practice is remarkably uniform and shows a decided preference for the aluminum-oxide-film and aluminum-cell types. However, the comments made on these types show that they do not provide all the protection that might be desired. In fact, some of the companies expressed doubt as to their justification on high voltages. Where companies have made consistent efforts to get definite data as to apparatus failures with and without arrester protection, the results occasion distrust as to the effectiveness of the protection afforded by arresters.

One company reports that in 1912 the use of lightning arresters was abandoned by it, and that since then the cost of maintenance has been materially reduced. It was felt that in this case the purchase of the best types of transformers was justified so that the lightning arresters could be dispensed with. Experience demonstrated that it was cheaper to have spare transformers than to repair the large and expensive aluminum-cell arresters.

Answers to Questions on Lightning Arresters

In Mr. Creighton's paper an endeavor is made to answer the questions of practice and criticism of lightning arresters brought out by the questionnaire. The author points out that an explanation for the satisfactory operation of the system without lightning arresters, as mentioned in the preceding paragraph, is found in the use of insulators of low arc-over voltage. Either the lightning potential is relieved locally at the insulators, or the resultant traveling wave is of too low voltage when it reaches the transformer to endanger the insulation greatly. It is pointed out that poor line insulation is not a solution of the problem of continuity of service. The use of no lightning arresters is discussed from three viewpoints: (1) If it is contended that lightning is not of sufficient voltage to cause damage; (2) if it is considered a better investment to put lightning-arrester money into spare transformers; (3) if it is considered good practice to so highly insulate a transformer as to give it immunity from lightning. The conclusion reached is that each of these three arguments is dangerously faulty.

Although the author gives considerable space to a discussion on the inspection and repair of aluminum-cell arresters in his paper, and suggests that the power factor of the cells, either as individual cells or as a stack, may be a desirable method of determining the condition of an arrester before deciding to disassemble the parts, considerable doubt was expressed by those who discussed the paper as to the reliability of this method. It was pointed out that it was possible to give to the arrester almost any power factor desired.

Attention is called to two 33,000-volt aluminum-cell arresters that had been in service for thirteen years without overhauling. When these arresters were disassembled, the cones were not corroded or eaten at the contact line of the oil and electrolyte.

A paper by E. E. F. Creighton, "Questions on the Economic Value of the Overhead Grounded Wire," also dealt with protection of power circuits and apparatus against lightning discharges. The author points out that overhead grounded wires have been in extensive use since the construction of the earliest transmission circuits, to protect these circuits from lightning discharges, and that it might be erroneously inferred that several decades of use of the overhead grounded wire had established by practice its value. The conclusion is drawn that the expense of overhead grounded wires on wooden-pole lines is, in general, an economic waste. In particular cases it may be justified; on metal-tower construction the use of the overhead grounded wire is in general fully justified. The analysis in this paper was made for presentation to a public service commission. This commission, on reconsideration, reversed its order that an overhead grounded wire should be installed on a 13,000-volt transmission circuit supported on wooden poles.

Discussion on Overhead Grounded Wire

It was evident from the discussion on this paper that many were of the opinion that the conclusions against the use of overhead grounded wires on wooden-pole lines were not borne out by practical experience. It was the general consensus of opinion that if ground wires are properly installed they give considerable protection to power circuits against lightning. It was pointed out that the chief trouble with grounded wires has been that they have not been properly installed and maintained. The same class of construction should be used on the grounded wire as for the power wires. Attention was called to one case where a great deal of trouble was being experienced on a wooden-pole line without an overhead grounded wire, from lightning splitting the poles. This trouble was overcome by placing a metal band around the top of the poles and grounding this band.

Dr. C. P. Steinmetz expressed the opinion that the overhead grounded wire was the most valuable and effective device for protection against lightning discharges. If he were allowed to use only an overhead grounded wire or a lightning arrester, he would choose the overhead grounded wire.

Others, taking part in the discussion, agreed with the conclusions arrived at by the author of the paper. Some of them expressed the opinion that in certain cases the overhead grounded wire did more harm than good.

Petersen Earth Coil

"The Petersen Earth Coil," by R. N. Conwell and R. D. Evans, gives the results of some experiments on a device for suppressing accidental grounds. The essential part of the Petersen coil is a suitable reactor connected between the neutral of the circuit and ground. The reactor is chosen of such a value as to neutralize the capacitance of the circuit when an accidental ground on one phase takes place. In a comparison of the various methods of grounding and their effects on the operation of a power system the solid and the low-resistance grounds assume first and second place in order of desirability. The distinction, however, between the two is slight and choice will be determined by local conditions. Either the Petersen earth coil or the critical-resistance ground will assume third place in the order of desirability, as the relative advantages and disadvantages of these two are about equal.

In a paper, "The Effects of Moisture on the Thermal Conductivity of Soils," by G. B. Shanklin, the results of tests made on the thermal conductivity of soils having different percentages of moisture are given. It is shown that moisture in soils surrounding electric cables plays a predominant part in assisting the dissipation of heat generated within the cables. The addition of moisture to the soil increased the thermal conductivity range five times or more over that for dry soil.

"Five Hundred Tests on the Dielectric Strength of Oil," by J. L. R. Hayden and W. N. Eddy, is the title of a paper that gives the results of 500 successive breakdown tests taken on a two-millimeter gap, between spheres, one centi-

meter diameter in transit oil. Because of the well-known inconsistency of breakdowns in oils these observations showed wide variation in voltage required to cause failure. In the discussion it was pointed out that much more consistent results are to be obtained with larger electrodes and longer gaps such as used in making standard tests. It was felt that when a group of tests showed high breakdown values, the oil was in good condition, and when low values were obtained for a group of tests something was wrong with the oil.

At the Thursday morning session E. B. Shand presented the fourth paper, "An Analytical Investigation of the Causes of Flashing of Synchronous Converters," which shows on what factors the flashing tendency of rotary converters depends and how an improvement of their momentary overload characteristics can be obtained. Synchronous stability, stability of commutating conditions and means of choking down the flash are the methods enumerated by which the momentary overload capacity may be increased.

In the discussion the results of short-circuit tests on 750-volt 60-cycle converters and methods of preventing flashovers at the commutator were shown. By the use of suitable flash barriers and arc deflectors it has been made possible for the 60-cycle 750-volt rotary to withstand a dead short-circuit without flashing over, where the momentary current exceeds twenty times full-load value. Sixty-six such tests had been made successively on one machine without causing any serious effects. It is considered that the 60-cycle rotary can compete with the motor-generator set in stability and reliability of operation.

Edison Medal Presented to Mr. Chesney

The principal event of Thursday evening at the A. I. E. E. Midwinter Meeting was the presentation of the Edison medal for 1921 to Cummings C. Chesney, chief engineer and manager of the Pittsfield (Mass.) works of the General Electric Co. Before the formal presentation of the medal, Prof. Homer A. Adams, chairman of the Institute's Edison Medal Committee, explained what the medal stands for, and William C. Jackson, of the New York Edison Company, gave an insight into the pioneer development work for which the medal has been awarded to Mr. Chesney.

Mr. Jackson drew upon his early association with Mr. Chesney and gave as the keynote of the man's character his pioneering spirit. It made no difference how many people said that a thing could not be done, he pointed out; Chesney simply said "It must be done," and went about doing it with success that is widely known. He gave a further insight into his friend's character when he said that in all the time he had known him he had never heard him ask any of his associates to work harder—they put their utmost effort into their work or they soon dropped out, but they were never driven. He called his hearers' attention to the fact that the recent experiments in which electricity has been produced and controlled at 1,000,000 volts were made at Mr. Chesney's plant under his general direction.

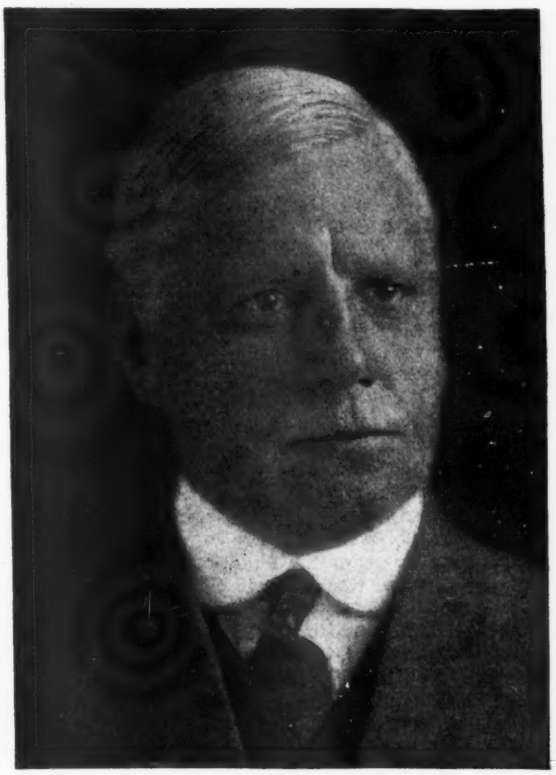
President William McClellan, of the Institute, spoke briefly of Mr. Chesney's achievements and presented him with the medal as "an example to your profession and a testimony to your character as a man."

In accepting the medal and expressing his appreciation of the honor conferred upon him, Mr. Chesney paid his respects to Thomas Edison with the humorous suggestion that he remembered Mr. Edison well because of their early battles on the question of direct-current vs. alternating-current.

Mr. Chesney sketched the most interesting events in his career, the first of which was his meeting with William Stanley two years after being graduated from Pennsylvania State College. He joined Stanley in his laboratory at Great Barrington, Mass., and the result of this association was that he turned his attention from experimental chemistry, in which he had previously specialized to a large extent, and from that time on devoted his efforts almost entirely to the development of electrical machinery, particularly with regard to the use of alternating-current. After an intervening year or two with the Westinghouse Electric and Manufacturing Co. at Newark, N. J., he went to Pittsfield, Mass., in 1890, when he joined Stanley and John Kelly in the incorporation of the Stanley Electric Manufacturing Co., which later became the Pittsfield works of the General Electric Co.

In telling of his early development work and of the fight to establish the practicability of alternating current, Mr. Chesney modestly pointed out that discoveries and inventions in the field of science are never isolated events, but rather are simply slight additions to already existing knowledge. The medal that he has received, however, constitutes recognition of his leadership in electrical development.

The Edison medal was founded by the Edison Medal Association, which is composed of associates and friends of Thomas A. Edison, and is awarded annually "for meritorious achievements in electrical science, electrical engineering, or the allied arts." It was awarded for 1921 to Mr. Chesney, on Dec. 8, "for early development in alternating-current transmission." It represents the highest honor in the country that can be given for electrical work; among those who have received it may be mentioned George Westinghouse, William Stanley (Chesney's early associate), Alexander Graham Bell and Nikola Tesla.



CUMMINGS C. CHESNEY, THE 1921 EDISON MEDALIST

The Spirit Lake Railway and Power Co. has filed an application for a preliminary permit for two proposed projects to be located immediately below its proposed Spirit Lake project. The upper development consists of three diversion dams in Toutle River, North Fork of Toutle River and Green River, respectively, and conduits leading to a common forebay and power house with an estimated capacity of 30,000 hp. The second development is to be located lower down on Toutle River, and consists of a concrete arch dam 40 ft. high and a tunnel and open flume 4½ miles long to a power house with an installed capacity of 20,000 horsepower.

The American Society of Heating and Ventilating Engineers has forwarded to the Federated American Engineering Societies copy of a resolution in which the Society commends the work of the Federated Societies during 1921 and pledges itself to join the organization as soon as its financial condition permits.

Coal Sampling on a Large Scale

A recent announcement of the Bureau of Mines states that work on the development of new types of coal-sampling apparatus is being done at the Washington office of the Bureau under the direction of O. P. Hood, chief mechanical engineer. The practicability of coal inspection on a large scale depends upon the development of sampling devices that can obtain a true representative sample with the least possible interference with transportation. This means the development of apparatus somewhat comparable with apparatus used for loading and unloading coal.

A machine has been developed that will drill a six-inch hole vertically through coal carried in a car and will abstract the cuttings. Complete detailed plans have been made for a single sampler adapted to take samples from truck loads at the Government Fuel Yard. General plans have also been developed for a multiple sampler adapted to take samples from open-top cars in a railroad train without distributing the train or unloading the coal. Only the reduced laboratory sample is to be taken from the sampler.

Developments on Muscle Shoals Bids

Before the Committee on Military Affairs of the House of Representatives will recommend consideration by the House of Henry Ford's offer for Muscle Shoals, it is becoming increasingly evident, as the hearings progress, that the offer will have to be modified. While several members of the committee would be willing for Mr. Ford to take over the project on his own terms, it is plainly to be seen that a vote to report out the proposition in its present form would be lost.

The effect of the offer of the Alabama Power Co. has been practically to insure the ultimate acceptance of one or the other offer or the completion of the Wilson Dam by the Government itself.

A detailed statement of the situation with regard to the Warrior-Gorgas plant was made to the committee by J. H. Burns, who until recently was in charge of the Nitrate Division of Ordnance. He explained that the Alabama Power Co. had in operation at the time of the war a 20,000-kw. plant on the Warrior River. So as to be insured power for the chemical end of the project before power could be made available at Muscle Shoals, a plan was worked out whereby the Alabama Power Co. was to furnish 30,000 kw. provided the Government increased the facilities at Gorgas. He explained that the plant cannot be divided since it is all under the same roof. The boilers are fed through the same intakes. The ash-disposal system and the coal-supplying apparatus are all one. "It would be just like unscrambling an egg to try to separate those two plants," declared Major Burns. Continuing, he said:

> The Alabama Power Co. agreed to put up this additional plant at cost plus 6 per cent, and definitely agreed that the company would buy back the plant from the Government at a specified time at a fair value, to be determined by a board of arbitrators, one of whom would be the Alabama Power Co.'s representative, one the Government's, and a third to be selected by the two. Since the time limit provided in the contract has not been reached, no negotiations for the return of the plant have been undertaken. In case the sale is not consummated to the Alabama Power Co., the Government must remove its portion of the plant and leave the land in satisfactory condition.
>
> The arrangement was an expedient to get quick power in order to get explosives at No. 2 plant. It seemed to be the very best solution that could be made of the problem at that time. This arrangement with the Alabama Power Co. was a great help to the Government in the early days because it gave us power at the No. 2 plant in May, 1918, a few months after the plant was started, and we never were short of power as a result of that connection. Our own steam plant at Muscle Shoals was not accepted finally until long after the Armistice. As it stands today we could run No. 2 plant practically at full capacity without this power plant at Gorgas, because we now have a 60,000-kw. plant at Muscle Shoals.

In that connection Representative McKenzie remarked: "With this contract and the plant put up in such a way as it is, absolutely impossible to separate the Government's interests from those of the Alabama Power Co., we are asked to consider as one of the items that enter into the proposal submitted by Mr. Ford, the delivery of a plant where the interest of the Alabama Power Co. must be bought out if we are to deliver him anything of value." This led Major Burns to say that if the Government tried to buy out the Alabama Power Co. at Gorgas, it would have to spend a great deal of money. In his opinion the amount would run into millions. Major Burns also pointed out that the Alabama Power Co. is not to pay salvage value but, in his opinion, a fair-going-concern value. He expressed the emphatic opinion that the inclusion of the Gorgas plant in the Ford proposal makes it an impracticable proposition. The Government can expect to receive about $3,000,000 for the Warrior plant if it is turned back to the Alabama Power Co., he estimated.

In explaining the difference between the Alabama Power Co.'s contract and that with the Air Nitrates Corporation, Major Burns said: "The American Cyanamid Co. cannot buy Plant No. 2 unless it is willing to make as good a proposition to the United States as the United States is able to get from any other person. It is my judgment that the American Cyanamid Co. would not give the United States as much as Mr. Ford is agreeing to give. Therefore, I feel that the American Cyanamid Co.'s option will not be an impediment"

One Million Dollars Enough for New York's Hydro Project?

At a public hearing held Feb. 22 at the State Capitol, Albany, on the Robinson bill, which appropriates $1,000,000 for hydro-electric development of the power at Crescent Dam and Vischer's Ferry on the Mohawk River, the principal trend of the discussion was the inadequacy of the proposed appropriation.

Samuel F. Moran, representing the Cohoes Light and Power Co., said that the appropriation was insufficient to carry out the project and that full development of the sites would involve expenditure of approximately $6,000,000. Charles L. Cadie, state superintendent of public works, in defense of the measure, declared himself confident to go ahead with the task of developing the two sites with the appropriation contained in the bill.

The main arguments were centered around the question of lowering the waters of the barge canal by development of electric power to such an extent as to hinder navigation. Mr. Cadie declared that development of the surplus waters of the canal by private enterprise had in the past always resulted in lowering the level of the canal and interfering with navigation. He was seconded in his defense of the bill by George De Witt Clinton, grandson of Governor De Witt Clinton, the father of the Erie Canal.

Contending that the Cohoes Power and Light Corporation had already made application to the state water power commission for a license to develop water power on one of the sites, Mr. Moran declared that the passage of the measure would hinder the commission from granting the license. He said:

> There are available at the two sites 100,000,000 kw.-hr. per year. The expenditure estimated by our company as necessary for the development of the sites would be $3,500,000. The state would appropriate $1,000,000. I think it is safe to say that an appropriation of that amount would develop no more than one-third of the power. The state must be prepared to follow that appropriation with $2,500,000 or more. Then the state would have to invest $2,000,000 or thereabouts in a steam plant to piece out the production in order to insure a continuous flow of power.

In discussing the state's plan of development at the two sites, Mr. Cadie said the estimates considered a development of 5,000 hp. at each plant. "The bill," declared Mr. Cadie, "leaves the constitutional right to decide what is surplus water with the superintendent."

Several amendments were submitted providing for protection of the rights of individuals as well as for the rights of the state.

News in the Field of Power

A. S. M. E. to Visit Muscle Shoals

At the approaching spring meeting of the American Society of Mechanical Engineers, which is to be held May 8-11 at Atlanta, Ga., a feature of particular interest will be a visit to the Muscle Shoals development, which is receiving so much attention at the present time through the offer of Henry Ford and others to complete it for the Government.

Other features that will attract power-plant men to the convention are the following papers, which will be presented under the auspices of the Power Division: "Power Development In the Southeast," by Charles G. Adsit, consulting engineer of the Georgia Railway and Power Co.; "Hydro-Electric Power-Plant Design," by John A. Sirnit, designing and electrical engineer of the Alabama Power Co.; "Economics of Water Power Development," by Curtis A. Mees, consulting engineer, of Charlotte, N. C.

To Link Business and Engineering

A conference with the object of working out better methods for the business training of the engineer and the engineering training of business students is to be held May 1-2 at the Carnegie Institute of Technology at Pittsburgh. It is being arranged for by the United States Commissioner of Education, who will send out invitations to appoint delegates to commercial and trade organizations, engineering and scientific societies, educational institutions and other groups as well as to prominent individuals. The general public, however, will be entirely free to attend the conference.

The purposes and scope of the meeting are well set forth in the following statement:

Outstanding topics at the Pittsburgh Conference will deal with the new problems that have recently arisen in modern industries, the solution of which demands a more scientific approach to include job analyses and personnel specifications and a translation of these into a new and teachable content for use in our engineering and commerce schools; with the training of the engineer for a better understanding of problems relating to community development; and with the training of the engineer for management of over-seas engineering projects.

The committee in charge of preparations for the affair includes well-known engineers and business men and deans of schools of engineering and of commerce in our larger universities, and is headed by Dr. Glen Levin Swiggett, of the United States Bureau of Education. The same committee conducted a similar conference in Washington two and a half years ago, which was the first of its kind. It is felt by Dr. Swiggett that the coming meeting will have even greater national significance than the first one, because of the timeliness of the subject to be discussed.

Boston Societies Prepare To Affiliate

The rapidly spreading movement toward the grouping together in each city of the various local sections of the national engineering societies is having its effect in Boston, where a plan of affiliation has been worked out and is now being considered by the organizations concerned. The plan was accepted in principle by the local sections of the American Society of Mechanical Engineers, the American Institute of Electrical Engineers and the American Society of Heating and Ventilating Engineers at a joint meeting on Jan. 24. It was agreed that each of these three societies should appoint two representatives to talk the matter over with representatives of the other local technical organizations, which is now being done. It is hoped that definite action may be had some time in March.

HE WHO merely knows how to read the simplest words has at his call the key to most knowledge. To make that knowledge his merely requires the will to do. Books are the servants and tools of those who open their pages and read. The dictionary explains the meaning of words, and its covers are not held closed except by those imaginary bolts and bars of inertia. Any man who mopes around, bemoaning the fate that denied him an education, is wasting the time which, properly applied, will give him knowledge. Ten chances to one that man can tell how many homers "Babe Ruth" made last season and has the records of baseball and pugilism at the tip of his tongue. He discourses learnedly on the merits of upper cuts and scissors locks, double nelsons and cross-buttock holds. Therein lies the knowledge he craves, therefore he makes it his own. But the knowledge that would fatten his pay envelope—well, he didn't want it.

Spain Considering Ebro River Development

An irrigation and power development on the Ebro River in Spain is being given serious consideration in the Spanish parliament. The development of a fairly large amount of seasonally intermittent water power and the irrigation of about 275,000 acres of land would be made possible by a dam in the headwaters of the Ebro at Reinosa, in the Province of Santander. Some of the equipment that will be required by such a project is not manufactured in Spain, and so must be purchased abroad.

Might Have Been Worse

"Reports to this office from widely scattered localities indicate that the falling off in employment has not been so great as most people had anticipated," says Col. Arthur Woods, of the President's Conference on Unemployment, in a recent bulletin sent out to mayors of all cities of more than 20,000. He adds:

If general business conditions keep along about the same until spring, doubtless the situation will depend largely upon the severity of the winter. There is no doubt that the manner in which cities throughout the country generally have organized to meet the emergency, has had and will continue to have a very strong and mitigating effect. If it had not been for this potent factor, those best fitted to know are inclined to think that there would have been before now, many serious situations.

What the Research Laboratory at Pittsburgh Is Doing

A good idea of the activities of the Research Laboratory conducted at Pittsburgh by the American Society of Heating and Ventilating Engineers, in co-operation with the Bureau of Mines, is given by the program of work that is being undertaken this year, and which is as follows:

Radiant heat loss of steam radiators; heat losses from pipes buried in the ground; circulation of water in hot-water systems; heat losses through various building materials; electrical method of testing radiators; infiltration through various forms of building construction; relation between outside wall temperatures and dew point; standardization of dust measurements; checking application of heating-boiler testing code; standardization of pipe sizes; study of combustion in domestic heating boilers; economy of burning mixed gases; heat loss through glass; chimney investigations; economy of the gas grate; transfer of heat from steam to liquids of various densities; temperature and humidity effects on health; ventilation problems; industrial dust elimination; velocities necessary to move materials; wet-bulb temperatures most effective in dehydration problems; effect of use of ozonators; minimum volume of air for ample ventilation; correct method of air distribution for most effective results.

Upon the death a few months ago of the laboratory's first director, Dean John R. Allen, it was able to secure as its new director Dean F. Paul Anderson, of the College of Engineering of the University of Kentucky, who took charge Aug. 1, 1921. The experience of Dean Anderson fits him well for his work. Directly after his graduation in

1890 he went to the State College at Lexington, Ky., where he has remained ever since, with increasing responsibilities. At the same time with his University work, he was for twenty-five years engineer of tests for the Southern Railway Co. and carried on a consulting engineer practice in Lexington and vicinity.

The laboratory has available elaborate apparatus for research in the profession of heating and ventilating and for the testing of equipment and apparatus used in such work. It is allowed all the space that it needs in the Bureau of Mines Building, and is also supplied by the Government with steam, heat, water, compressed air, etc., so that a great many thousands of dollars per year are being contributed to the work by the Government. On the other hand, however, it is suggested that the activities of the laboratory are so important to the ultimate health and economic welfare of the whole population that it ought to be completely a Government undertaking, as it was in Germany, instead of being carried on largely by the American Society of Heating and Ventilating Engineers, a national body, with headquarters at 29 West 39th St., New York City.

New Publications

The Unaflow Steam Engine. By Prof. J. Stumpf, Published by the Stumpf Unaflow Engine Co., Syracuse, N. Y. Size, 8 x 10½ in., 315 pages; 332 illustrations.

The new English edition of Professor Stumpf's book is something more than a translation of the new German edition and, as stated in the preface, represents a complete revision of the first edition. That Professor Stumpf has been following consistently a logical development is illustrated by the similarity between the original sketch of a unaflow engine made by him in the year 1900 and the drawings of his latest design as it appears in Figs. 2 and 3 of the Preface.

The true skeleton of the new arrangement is stated in the main Chapter I, under the head of "Steam Engine Losses." Stumpf states that the losses in a steam engine may be classified as follows: (1) Losses due to cylinder condensation (surface loss); (2) losses due to the volume of the clearance space (clearance volume loss); (3) loss due to throttling or wiredrawing; (4) friction loss; (5) loss due to leakage; (6) loss due to heat radiation and convection; (7) loss due to incomplete expansion. He then sets out to show how his design of unaflow engine may be adapted to reduce all these losses to a minimum and thereby improve the performance of the reciprocating steam engine to a point where it makes possible in the small plant, efficiencies as good as those obtained by the largest steam turbines.

Among other interesting chapters is the one dealing with unaflow engines arranged for bleeding, or taking off steam during expansion after it has done some work in the cylinder. While this chapter does not contain much new matter, the subject seems to be one of importance, especially for textile plants and other places on chemical industries where a small amount of steam is needed for process work, as compared with the amount of power required. This chapter shows that the unaflow engine is equally well adapted to this kind of service when compared with a turbine.

Ehrhardt & Sehmer are mentioned as originators of most of the designs shown of the unaflow rolling-mill engine, both for flywheel and reversing-type engines. So far as known, no unaflow engine of the reversing type for rolling mills has yet been built, although several designs have been made. The two largest engines that are known to be in operation are one 67-in. diameter x 55-in. stroke built by Ehrhardt & Sehmer and another 60-in. diameter x 71-in. stroke, built by Galloways, Ltd., of England. A still larger engine, 76-in. bore x 72-in. stroke, has been designed for a rolling mill in the United States by the Mesta Machine Co., of Pittsburgh.

The chapter on locomotives in this edition contains a good many of the older photographs, but seems to make one striking contribution to the development. This is the use of the energy in exhaust steam not only to produce the draft for the fire, but also to reduce the back pressure in the cylinders.

There is also shown a design of a V-type, four-cylinder, single-acting unaflow engine for automotive purposes, as designed by the Stumpf Unaflow Engine Co., Inc., Syracuse, N. Y., for a light truck or passenger car. Similar engines were designed, built and tested in a motor truck and also in a high-pressure steam tractor. The application of the ejector exhaust principle to this type of engine might further assist in its development, which was greatly retarded during the war.

In the last chapter Professor Stumpf takes up his novel design of single-beat valves and double-speed layshaft, with various modifications. He goes a little further in theory and also a little bit further in showing modifications of his design than he did in the article which was published in *Power*, June 28, 1921. Probably everybody will agreee with him on the desirable simplicity of the single-beat poppet valve. The object of his design is to provide a valve gear that will give a single-beat valve high enough lift with the short cutoffs used in a high-pressure condensing unaflow engine to prevent heavy throttling losses. The mechanical device of combining two eccentrics running at different speeds to obtain these results is clever enough. By increasing the speed of his main layshaft, the size of his governor may also be reduced. Whether there will be sufficient demand for an engine to operate on high steam pressures and low vacuums, for which this design seems especially suited, will in this country depend largely upon the rising importance of the cost of fuel. There is no doubt that the tendency is now in this direction. There are few industrial plants, however, where the cost of fuel represents more than 15 per cent of the total production cost of the manufactured output, so that it will require more than a small percentage of saving in fuel to justify an engine with any valve-gear complications that will add materially to its first cost. The practical application of Professor Stumpf's clever design, therefore, rests with the future.

It would appear that the volume may be a valuable contribution to the development of the reciprocating steam engine far beyond what was ever considered possible. The book not only describes what has been done, but points the way for new progress and new utilization of the fuel economies possible by using higher pressures and temperatures of steam and lower back pressures.

The book merits reading by all who are responsible for the development of power from fuel, especially in smaller units, and it warrants careful study by every engineer who has to do with the design, purchase or operation of prime movers.

Obituary

Albert C. Ashton, for 20 years treasurer of the Ashton Valve Co., of Boston, Mass., died Jan. 31 at St. Petersburgh, Fla. He was born in England 52 years ago and came with his family to this country while still a schoolboy, settling in Somerville, Mass. He was graduated from Chauncy Hall School and from the Massachusetts Institute of Technology. He was prominent in the Mason's fraternity, in the First Methodist Church of Somerville, in the civic affairs of Somerville and in the A. S. M. E., having once been chairman of the Boston Section of the Society and also active in committee work.

William C. Sargent, for 22 years secretary, and also a director, of the Chain Belt Co., of Milwaukee, died suddenly Feb. 5 from heart failure. He was 73 years old and had been in ill health for some time.

Mr. Sargent was born at Troy, New York, Feb. 2, 1849. In 1871 he moved West, locating at St. Paul, where he organized the De Cou, Corliss & Sargent Co., manufacturers of sash and doors. He later became affiliated with the St. Paul Harvester Co. and met C. W. LeValley, who afterward founded the Chain Belt Co., of Milwaukee. In 1900 Mr. Sargent went to Milwaukee to become secretary and later a director of the Chain Belt Co. He was also a director of the Federal Malleable Co., West Allis, Wisconsin. His father was one of the founders of the Terre Haute, Alton & St. Louis Railroad.

Society Affairs

Coming Conventions

American Society of Mechanical Engineers—Spring meeting at Atlanta, Ga., May 8-11. Secy., Calvin W. Rice, 29 West 39th St., New York City.

National Electric Light Association—Annual convention at Atlantic City, N. J., May 15-20. Headquarters, 29 West 39th St., New York City.

Philadelphia Section, A. I. S. E. E., will meet March 4 for an address by J. K. Ostrander, of Dwight P. Robinson & Co., on "Automatic and Remote Controlled Substations."

The Engineers Club of Kansas City is to hold an extensive co-operative meeting on March 6 and 7, at which the petroleum industry will be considered in all its phases.

Providence Section, A. I. E. E., will hold a joint meeting with the Power Section of the Providence Engineering Society, March 7, at which Robert B. Lea, engineer of the Sperry Gyroscope Co., will speak on the subject of the Sperry gyroscope. He will also take up other inventions of Mr. Sperry, including the compound Diesel engine.

Providence Section A. S. M. E., will meet March 10 to hear an address on "Heat Balance in Power Plants," by Leo Loeb, mechanical engineer with Day & Zimmerman, of Philadelphia.

Business Items

The Harrisburg Foundry and Machine Works has opened offices in the Walton Building, Atlanta, Ga.

The American Steam Gage and Valve Manufacturing Co., Boston, Mass., has opened a new branch office in the Real Estate Trust Building, Philadelphia, in charge of L. E. Gebhardt, formerly district manager for the Yarnall-Waring Co., of Philadelphia.

The Public Service Production Co., 80 Park Place, Newark, N. J., has been organized with N. A. Clark as vice president and general manager and E. B. Meyer as chief engineer. Its work will include the design and construction of power and industrial plants, the valuation and management of public utilities, and similar activities.

The Cement-Gun Construction Co., 537 South Dearborn St., Chicago, Ill., has announced the association with it of C. L. Dewey, who will devote his time exclusively to the development of cement-gun contract work. Mr. Dewey and Carl Akeley developed the device, and Mr. Dewey has used it in contract work under the names of the Dewey Cement-Gun Co. and the Traylor-Dewey Contracting Co.

Trade Catalogs

Cableway Apparatus—Deschanel Engineering Corporation, 90 West St., New York City. A short bulletin on a cableway outfit, which has a bucket of either ¾ or ½ cu.yd. capacity, suitable for reclaiming coal from storage to bunkers or boiler-room floor and removing ashes to railroad cars, trucks, or ground or overhead storage.

Boiler Tubes—National Tube Co., Frick Building, Pittsburgh, Penn. Bulletin No. 16-D, "Manufacture and Advantages of 'National' and 'Shelby' Boiler Tubes," of especial scientific interest because of a number of photographs of tubes that have been tested to destruction and because of the discussion and results of the company's tests of tubing.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine-run bases, f.o.b. mines):

Coal	Market Quoting	Feb. 13, 1922	Feb. 20, 1922
Pool 1,	New York	$3.00	$2.75@3.25
Pocahontas,	Columbus	1.90	2.00@2.20
Clearfield,	Boston	1.95	1.70@2.25
Somerset,	Boston	1.90	1.75@2.00
Pittsburgh,	Pittsburgh	2.15	2.10@2.20
Kanawha,	Columbus	1.65	1.50@1.85
Hocking,	Columbus	1.90	1.75@2.00
Pittsburgh No. 8	Cleveland	1.95	1.95@2.00
Franklin, Ill.,	Chicago	2.50	2.25@2.75
Central, Ill.,	Chicago	2.35	2.25@2.50
Ind. 4th Vein,	Chicago	2.50	2.35@2.65
Standard,	St. Louis	1.90	1.85@2.00
West Ky.,	Louisville	1.85	1.70@2.00
Big Seam,	Birmingham	1.85	1.75@2.00
S. E. Ky.,	Louisville	1.65	1.50@1.65

New York—On Feb 21, Port Arthur light oil 22@25 deg. Baumé 4c per gal. 30@35 deg., 5c. per gal., f.o.b. Bayonne, N. J.

Chicago—Feb. 21, for 24@28 deg. Baumé, 85@90c. per bbl.; 32@36 deg., 2⅜@2½c. per gal. in tank cars f.o.b. Oklahoma refinery, or freight adjusted.

Pittsburgh—On Feb. 21, f.o.b. refinery, Pennsylvania, 38@40 deg. 4c@4¼c. Kentucky fuel oil, 26@30 deg., 3c. per gal.

St. Louis—Feb. 18, prices f.o.b. cars, tank lots; 24@26 deg. Baumé, 75c. per bbl.; 26@28 deg., 85c.; 28@30 deg., 95c.; 32@34 deg.. 2¼c. per gal.

Philadelphia—On Feb. 20, 26@28 deg. Baumé, Oklahoma, 90@95c. per bbl.; 30@34 deg., Oklahoma (group 3) 2¼@2⅜c. per gal.; 16@20 deg., Seaboard, $1.10@$1.25 per bbl.

Cincinnati—Feb. 20, for 26@30 deg. Baumé, 5c.; Diesel 32@34 deg., 5¼c. per gal.; distillate 38@46 deg., 6c. per gal.

Cleveland — Feb. 20, 26@30 deg. Baumé, 4c. per gal.

New Plant Construction

PROPOSED WORK

Ariz., Prescott—The Treasury Dept., J. A. Wetmore, Supervising Archt., Wash., D. C., will receive bids until March 23, for the installation of two new boilers and mechanical changes in the cold storage and ice plant building at the U. S. Veterans Hospital No. 50 at Whipple Barracks, here.

Cal., Crows Landing—The West Stanislaus Irrigation Dist., Stanislaus County, is having plans prepared for works; calls for 500 cu.ft. per second from the San Joaquin River by dredged canal 1¼ mi. long, then by lifts to successive stages of open channel or pipe. Centrifugal pumps, ranging from 12 to 72 cu.yd. second with total capacity of 250 cu.yd.; second being considered. L. McAulay, Newman, Secy., E. N. Bryan, 601 Clunie Bldg., San Francisco, Engr.

Cal., Dixon—Rosenthal & Davis, Humboldt Bank Bldg., San Francisco, Engrs., have completed surveys for proposed works of East Dixon Irrigation and Drainage Assn., to divert water from Sacramento river by means of a 9 mile cut or 7.5 miles of slough, to irrigate between 64,000 and 100,000 acres. Water to be distributed by following pumping plants:—Six 42 in. centrifugal pumps, 230 hp.; four 42 in. 260 hp.; two 42 in. 280 hp.; two 30 in., 100 hp.; one 30 in., 125 hp. All pumps to be double suction, split case centrifugal type. Estimated cost about $2,000,000. F. F. Swain, 1421 Bway., Oakland, Chn.

Cal., Fresno—B. Rogers, Las Palmas Ave. and J. Patterson, plans to build an 8 story, 150 x 175 ft. store and office bldg. on Tulare and J. Sts. About $600,000.

Cal., Grass Valley—F. H. Tibbetts, Engr., Alaska Commercial Bldg., San Francisco, completing plans for works in Nevada Irrigation District. A distribution system to include about 212,000 acres is planned, also 6 mile canal, dam 46 ft. high, 190 ft. long on bottom and 350 ft. long on crest. Estimated cost between $4,000,000 and $4,500,000.

Cal., Merced—The Merced Irrigation Dist. voted $12,000,000 bonds for work in district, $2,500,000 to be used to purchase system of Crocker-Huffman Land Co. New work will include dam 300 ft. high, 800 ft. long, cost $3,753,000; power house, 43,000 hp., $2,000,000, relocation of 25 mi. Yosemite Valley R.R., $2,043,000; repairing present canals, $100,000; constructing new canals, $1,422,000; pumping plants, Booster plants, $102,000; Booster laterals, $64,000; drainage, pumps and canals, $200,000. R. C. Starr, Ch. Engr.

Cal., Oroville—The Butte County Supervisors authorize formation of Thermalto and Table Mountain Irrigation Dists.—Thermalito comprising about 3,000 acres and Table Mountain 4,800 acres. Construction in both districts include earth dam (Concow Valley Dam) 70 ft. high, 20 ft. wide on top, 500 ft. long and 75 ft. wide on bottom; Earth dam (Lake Madeline Dam) 39 ft. high, 1,851 ft. long on bottom and 12 ft. wide on top. ditches and pipe lines. J. M. Howells, 58 Sutter St., San Francisco, Engr. S. J. Norris, Oroville, resident Engr.

Cal., Pomona—The Bd. Educ. will receive bids until March 7 for a 2 story, 160 x 275 ft. high school including a steam heating system. About $450,000. W. H. Week and R. Orr, 1301 Van Nuys Bldg., Los Angeles, Archts.

Cal., Suisun—The Suisun Irrigation Dist. is having plans prepared for 25 miles of canal, 4 dams, average 20 ft. high, 60 to 80 ft. long, earth storage dam, 90 ft. high, 810 ft. long on crest, 500 ft. long on bottom, 20 ft. wide at top. Total cost, $1,000,000. G. L. Dillman, 14 Montgomery St. and E. C. Cope, 58 Sutter St., San Francisco, Engr.

Conn., Allingtown (New Haven P. O.)—D. E. Smith, Archt., 152 Temple St., New Haven, is receiving bids for a 1 story manufacturing plant including a 40 x 50 ft. boiler house and garage, for the Velvet Textile Corp., P. O. Box 1962, New Haven. About $100,000.

Fla., Gainesville—The city, G. H. Cairns, City Mgr., will receive bids until March 6 for one turbo-generator set with direct connected exciter, capacity 625 K.V.A.; one low level jet condenser; one 30 K.W. motor generator set, with switchboard and all other necessary equipment. Robert & Co., Consulting Engrs., Red Cross Bldg., Atlanta, Ga.

Ia., Des Moines—The Bd. Educ., G. Garton, Secy., will receive bids until March 9 for a 3 story high school including a steam heating system on Park Blvd. and Center St. About $1,100,000. Former bids rejected. Proudfoot, Bird & Rawson, 810 Hubbell Bldg., Archts. Noted Feb. 14.

Ia., Muscatine—The city voted $350,000 bonds for municipal electric light and power plant. Noted Feb. 7.

Ill., Chicago—A. S. Alschuler, Archt., 28 East Jackson Blvd., is receiving bids for a 3 story, 100 x 300 ft. office, sales and service building including a steam heating system on 22nd and Michigan Ave., for the Hudson Motor Car Co., 25th and Michigan Ave. About $350,000.

Ill., Chicago—The Amer. Furniture Mart Bldg., Corp., c/o H. Reader, Archt., 20 West Jackson Blvd., is having plans prepared for a 16 story, 218 x 415 ft. furniture bldg. including a steam heating system on Erie St. near Fairbanks Court. About $5,000,000.

Ill., Chicago—The Chicago Mercantile Exchange, 136 West Lake St., plans to build a 14 story, 40 x 150 ft. office bldg. including a steam heating system on LaSalle and Lake Sts. About $2,000,000. Architect not selected.

Ill., Chicago—A. E. Sward, c/o T. R. Bishop, Archt., 35 South Dearborn St., is having plans prepared for a 3 story, 120 x 130 ft. apartment including a steam heating system on 70th St. near Crandon Ave. About $500,000.

Ind., Indianapolis—J. F. Wild & Co., 123 East Market St., is receiving bids for a 12 story, 30 x 120 ft. bank and office building including a steam heating system at 123-27 East Market St. About $1,000,000. F. S. Cannon, 21 Virginia Ave., Archt. Noted Jan. 11.

Ind., South Bend—The Bd. Educ. will receive bids until March 16 for a 1 story, 200 x 300 ft. school. About $600,000. Freyermuth & Maurer, 654 Farmers Trust Bldg., Archts. Noted Jan. 10.

Kan., Rosedale—The Bd. Admin. c/o J. A. Kimball, Bus. Mgr., is having plans prepared for a 3 story hospital building and power plant. About $300,000. R. S. Gamble, 1415 Fillmore St., Topeka, Archts. new boilers and generators will be installed.

Ky., Georgetown—A. M. Robinson is in the market for No. 5 and No. 7 or 8 gyratory crusher; 300 or 350 ft. free air per min. compressor, belt driven; 75,000 or 100,000 gal. tank and 75 ft. towers.

Ky., Louisville—The Bd. Educ., Dr. I. M. Bloom, Pres., 8th and Chestnut Sts., is having plans prepared for a girls' high school to be known as J. M. Atherton School. About $300,000. Joseph & Joseph, Francis Bldg., Archts.

Md., Baltimore—R. J. Gill, Keyser Bldg., is having plans prepared for a 10 story office building at 23 East Baltimore St. About $300,000. C. N. and N. Friz, Lexington Bldg., Archts.

Mich., Detroit—The Dept. of Parks & Blvds., 600 Marquette Bldg., E. G. Heckel, Purch. Agt., is in the market for one 75 hp. locomotive type boiler with 4 in. stop and ample safety valve.

Mich., Pontiac—The Pontiac Commercial Savings Bank plans to build an 8 story, 60 x 145 ft. office and bank bldg., including a steam heating system, boilers, and equipment. About $400,000. Smith, Hinchman & Crylls, 710 Washington Arcade, Detroit, Archts.

Minn., Albert Lea—J. Higgins, representing company now being formed, plans to build a 9 story hotel, including a steam heating system. About $400,000. F. D. Chase, Inc., 5301 Western Blvd., Chicago, Ill., Archt.

Minn., Columbia Heights (Minneapolis P. O.)—The city, J. Corr, City Mgr., plans to install pressure system to replace present gravity system, including tower and pumping equipment. About $58,000. J. W. Shaffer & Co., 916 New York Life Bldg., Minneapolis, Engrs.

Minn., Minneapolis—The city, W. R. Young, registrar of Water Dept., plans 130,000 gal. tower at 31st Ave. and Fillmore St., N.E., about $15,000 will install one 1,000 gal. per min. electric driven centrifugal pump, also one 1,000 gal. centrifugal pump at pump station to be erected at 36th St. and Lake Calhoun Sts.

Minn., St. Paul—The Bd. Educ., L. R. S. Fergusin, Comr., City Hall, is having plans prepared for a 2 story junior high school including a steam heating system in Hamline district. About $400,000. C. A. Hausler, City Hall, City Archt.

Mo., St. Joseph—The Bd. Pub. Wks. plan election April 11 to vote $300,000 bonds for an electric light plant. W. K. Seitz, City Engr.

Mo., St. Louis—Bishop J. J. Glennon, is having plans prepared for a 135 x 260 ft. high school on Cote Brilliante and King's Hwy. About $250,000. Address H. P. Hess, 4811 Cote Brilliante Ave., Archt.

Neb., Columbus—The Roman Catholic Church, is having revised plans prepared for a 4 story, 45 x 145 ft. hospital including a steam heating system. About $300,000. C. Windeman Co., Columbus, Neb., Archt.

Nev., Fallon—The city will receive bids until March 28 for complete equipment and installation of additional water supply plant to include two electrically driven pumping units of 250 to 300 gal. per min. capacity each.

N. J., Bridgeton—R. McAllister, representing owner, is having preliminary plans prepared for a 6 story, 100 x 130 ft. hotel on Commerce and Pearl Sts. About $500,000. Dreher, Churchman, Paul & Ford, 1424 Walnut St., Phila., Pa., Archts. Noted May 17.

N. J., Camden—Ballinger Co., Archts., 12th and Chestnut Sts., Phila., Pa., will receive bids until March 20 for a 7 story factory and warehouse on Federal St. for the J. V. Van Scriver Co., c/o D. Jostro, Front and Federal Sts. About $500,000.

N. Y., Brooklyn—The Bd. Educ., 500 Park Ave., New York City, has had plans prepared for a 5 story, school No. 125, on Linden Ave. About $850,000. C. B. J. Snyder, Municipal Bldg., New York City, Archt. and Engr.

N. Y., Elmhurst—(Flushing P. O.)—The Bd. Educ., 500 Park Ave., New York City, has had plans prepared for a 3 story school No. 102, on Van Horn St. About $350,000. C. B. J. Snyder, Municipal Bldg., New York City, Archt. and Engr.

N. Y., Hailesboro—The St. Lawrence Transmission Co., F. A. Stoughton, Mgr., Potsdam, has purchased the hydro electric plant and development of the Uniform Fibrous Talc Co. on the Oswegatchie River and plans to install a 1,000 hp. generator unit.

N. Y., Hamburg—The village plans to build a pumping station. About $75,000. R. W. Hengerer, 12 Buffalo St., Village Pres.

N. Y., New York—The Bd. Educ., 500 Park Ave., plans to build a 204 x 224 ft. school, at 415-31 East 120th St. About $500,000. C. B. J. Snyder, 28th Floor, Municipal Bldg., Archt. and Engr.

N. Y., New York—The Bd. Educ., 500 Park Ave., plans to build a 200 x 350 ft. school on 2nd Ave., and 66th St. About $600,000. C. B. Snyder, 28th Floor, Municipal Bldg., Archt. and Engr.

N. Y., New York—The Broadway and 37th St. Corp., c/o Sommerfield & Steckler, Archts., 31 Union Square, is having plans prepared for a 16 story, 105 x 173 ft. showroom building on Bway. and 37th St. About $750,000.

N. Y., New York—R. & E. Jacobs, 542 5th Ave., plans to build a 14 story, 100 x 125 ft. apartment on 81st St. and Columbus Ave. About $1,500,000. Architect not selected.

N. Y., Riverhead—The Bd. Educ. is having plans prepared for a high school. About $250,000. Tooker & Marsh, 101 Park Ave., New York City, Archts. and Engrs.

N. C., Fremont—The city will receive bids until March 2 for deep wells, pumps, tower, tank, four miles pipe lines, etc. About $75,000. G. C. White, Durham, Engr.

N. C., Raleigh—The Carolina Power & Light Co. plans hydro electric development on Yadkin River near Swift Island Ferry, to develop about 40,000 hp. P. Tillery, Mgr.

O., Marion—The Marion Hotel Co., W. H. Holverslott, Pres., is having plans prepared for an 8 story, 80 x 140 ft. hotel on Main St. About $500,000. W. E. Russ & Co., 313 North Penn St., Indianapolis, Ind., Engr.

O., Painesville—The Bd. Educ., will receive bids until March 9 for a 2 story, 190 x 210 ft. high school including a steam heating system. About $295,000. F. L. Packard, New Hayden Bldg., Columbus, Archt. Noted Oct. 11.

O., Toledo—The city council, C. Schreiber, Mayor, plans to build a 3 story, 200 x 610 ft. city hall. About $2,000,000. Mills, Rhiners, Belman, Ohio Bldg., Archts.

O., Tippecanoe City—The town plans to vote $60,000 bonds for rebuilding and making additions to municipal electric light plant and water works. Address E. H. Kerr, A. Horney, Tippecanoe City.

Pa., Altoona—The School Dist., 6th Ave. and 15th St., W. N. Decker, Secy., will receive bids until March 6 for changing heating systems in High school, Grammar school and Lincoln school to connect with newly erected central heating and power plant. Includes changing from hot air to steam. About $30,000. Sherlin Eng. Co. Inc., 110 West 34th St., New York City, Engrs.

Pa., Erie—The Mutual Ice Co., plans to build a 1 story ice plant. About $60,000. A. C. Bishop & Co., 426 Guardian Bldg., Cleveland, Archts. and Engrs.

Pa., Pittsburgh—The Steelmasters Hotel Apt. Co., 419 Oliver Ave., plans to build an apartment hotel on Dirthridge St. About $6,000,000. F. C. Fisher Co., Inc., 419 Oliver Ave., Archt.

Va., Hampton Roads—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., received bids for a motor generator set and switchboard for the Naval Base Hospital here, from the General Electric Co., River Rd., Schenectady, N. Y., $16,860; W. G. Cornell Co., 19 Patterson St., Wash., D. C., $19,600; Allis Chalmers Mfg. Co., 118 East Pratt St., Baltimore, Md., $19,946. Noted Feb. 14.

W. Va., Athens—The town and State plans to construct a water supply system including a pumping station and filteration plant, for the State Normal School and town. About $75,000. C. E. Collins, Drexel Bldg., Phila., Pa., Engr.

W. Va., Spencer—The city, S. P. Bell, Mayor, has had plans prepared for an intercepting sewer, sewage pumping station and sewage treatment plant. About $90,000. C. E. Collins, Drexel Bldg., Phila., Pa., Engr.

Wis., Madison—The city, c/o H. C. Buser, Clk., City Hall, plans to build a 100 x 200 ft. city hall and municipal auditorium including a steam heating system. About $700,000. Architect not selected.

Wis., Milwaukee—Scott & Mayer, Archts., 445 Milwaukee St., will soon award the contract for a 5 story, 92 x 100 ft. hospital and a 2 story, 40 x 100 ft. nurses home on Grand Ave., for the Milwaukee Children's Free Hospital, 219 10th St. Cost between $350,000 and $400,000.

Wyo., Casper—The School Dist., W. O. Wilson, Secy., plans to vote an election for $500,000 bonds for a high school. Garbutt, Weidner & Sweeney, Casper, Archts.

Ont., Todmorden—R. O. Wynne Roberts, 40 Jarcis St., Toronto, Engr., has submitted report for water supply system including steel reservoir, pumping equipment, etc. Cost about $900,000. The program called for an expenditure of $90,000 initially.

Ont., Toronto—The city has had plans prepared steam heating systems for the Live Stock Arena, Exhibition Park, to cost $100,000 and $130,000 respectively. W. Price, City Hall, City Archt.

CONTRACTS AWARDED

Ill., Centralia—The city has awarded the contract for a 1 story, 50 x 103 ft. power house to the Beeson Mchy. Co., 308 Mutual Bldg., Kansas City, Mo., $82,600.

Ill., Chicago—The Fidelity Phoenix Fire Insurance Co., 175 West Jackson Blvd., has awarded the contract for a 9 story, 90 x 214 x 160 ft. office bldg. on Russ Cass and Pearsons Sts., to the Leonard Constr. Co., 37 South Wabash Ave. About $2,000,000. A steam heating system will be installed.

Minn., Hibbing — The Water & Light Comn., D. D. Haley, Secy., has awarded the contract for an addition to power plant and equipment to the Natl. Electric Constr. Co., 174 East 6th St., St. Paul, $134,680.

N. J., Secaucus—(Weehawken P. O.)—The Bd. Freeholders, W. O. Mari, Clk., has awarded the contract for a 2 story insane asylum consisting of various buildings including a power plant on County Farm to W. H. and F. W. Crane, 149 Bway., New York City. About $459,222. Noted Jan. 3.

N. Y., New York—The 509 West 155th St. Corp., c/o C. B. Meyers, Archt. and Engr., 31 Union Sq., will build a 6 story apartment on West 155th St. About $450,000. A steam heating system will be installed. Work will be done by separate contracts under supervision of Archt.

O., Ashtabula—The city has awarded the contract for a 1 story, 80 x 80 ft. power plant to Alexander Bros., 426 Williamson Bldg., Cleveland. About $100,000. Former contract rescinded. Noted Nov. 8.

Wis., Ellis Jct. (Crivitz P. O.)—The Wisconsin Public Service Co., 425 East Water St., Milwaukee, has awarded the contract for a hydro-electric plant 40 ft. head, 2,600 hp., along the Peshtigo River to J. R. McDonald, Black River Falls. About $200,000. Noted Feb. 14.